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BULLETIN
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Growth of Excised Tomato Roots in a Synthetic Solution

WILLIAM J. ROBBINS AND MARY BARTLEY SCHMIDT

(WITH TWO FIGURES)

The authors have previously reported (3, 4, 5) that a solution of mineral salts, cane sugar and thiamin (or the vitamin thiazole, 4-methyl-5β-hydroyethyl thiazole) appeared adequate for unlimited growth of excised tomato roots. At the time of the previous report the excised roots had been grown through 12 successive passages extending over a period of one year in a solution of mineral salts, pure cane sugar and thiamin and through seven successive passages extending over 7 months in a solution of mineral salts, cane sugar and thiazole. These roots have been kept in cultivation and those in the thiamin solutions are now in their 29th passage while those in the thiazole solutions are now in their 23rd passage. Since they are still growing with no evidence of a progressive diminution in growth or the development of abnormalities it would appear that these solutions are adequate for unlimited growth. Because of the long period of time through which the cultures have been maintained it seems desirable to record the results and to make some comments on them.

The clones of excised roots used in these experiments came originally from the germinated seeds of a pink fruited variety of tomato from Mexico, Ajo de Verrado, *No. 580*. Excised tips from the seedling roots were placed in White's solution (8), Sept. 29, 1935. After 13 passages in this solution subcultures were started Oct. 21 and 22, 1936 in a solution of minerals, cane sugar and thiamin. The subcultures in the thiazole solutions were begun Apr. 11, 1937 after 18 passages in a solution of minerals, sugar and yeast.

The excised roots were grown individually in 40 or 50 ml. of solution in 125 ml. Erlenmeyer flasks of Pyrex glass. The mineral salts were of chemically pure grade and the cane sugar was Pfanstiehl's chemically pure sucrose. The thiamin was Merck's synthetic. Two samples of thiazole

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have been used both furnished through the courtesy of Merck and Company. The first sample was dark in color and obviously impure, the second

TABLE 1

Growth of excised tomato roots in solutions of minerals, pure cane sugar and thiamin through 25 successive passages.

DATE	PASSAGE	NO. ROOTS WEIGHED	DRY WT. PER ROOT MG.	RANGE DRY WT. MG.	SOLUTION
1936					
Oct. 21, 22	14	8	4.5	0.8– 7.3	Wh
Nov. 24	15	7	7.1	2.7–17.1	Wh
Dec. 26, 27	16	5	4.6	1.6– 5.5	Wh
1937					
Jan. 30, 31	17	7	4.0	1.4– 5.6	Wh
March 5, 6	18	7	4.4	0.9–10.4	Wh
Apr. 6	19	9	7.5	2.6–23.1	Wh
May 8	20	14	11.5	1.9–26.7	Wh+B and Zn
June 9	21	6	16.5	10.7–25.4	Wh+B and Zn
July 16	22	6	7.5	5.2– 8.2	Wh+B and Zn
Aug. 23	23	7	5.6	0.4– 9.6	Wh+B and Zn
Sept. 27	24	5	3.0	2.1– 5.4	Wh+B and Zn
Oct. 19	25	4	8.3	6.0–11.2	Wh+B and Zn
Nov. 15	26	4	7.3	0.6–13.2	Wh+B and Zn
Dec. 14	27	4	1.6	1.1– 2.0	Wh+B and Zn
Dec. 14	27	6	9.9	4.0–19.8	Pf+B and Zn
1938					
Jan. 30	28	9	1.1	0.2– 5.2	Pf+$\frac{1}{2}$B and Zn
Mar. 3	28	9	0.8	0.2– 2.6	Wh+$\frac{1}{2}$B and Zn
Mar. 17	29	2	1.2	0.4– 2.0	Wh+$\frac{1}{2}$B and Zn
Apr. 12	30	3	0.1	0.1	Wh+$\frac{1}{2}$B and Zn
Apr. 12	30	5	0.8	0.1– 2.7	Pf+$\frac{1}{2}$B and Zn
May 16	31	4	3.2	0.1–12.3	Pf+$\frac{1}{2}$B and Zn
May 16	31	4	0.2	0.1– 0.3	Wh+$\frac{1}{2}$B and Zn
May 16	31	5	0.5	0.1– 1.2	Wh+Sol Z $\frac{1}{2}$
June 14	32	4	3.8	2.1– 8.2	Pf
July 12	33	9	9.9	6.3–16.8	Pf
Aug. 3	34	10	5.5	4.0– 6.8	Pf
Sept. 15	34	4	3.3	2.7– 4.3	Pf
Aug. 25	35	11	4.6	3.1– 8.6	Pf
Oct. 18	35	5	3.1	2.6– 3.6	Pf
Sept. 15	36	3	2.7	2.3– 2.6	Pf
Oct. 18	37	10	3.6	3.0– 5.0	Pf
Oct. 18	37	5	4.6	3.9– 5.6	Pf+$\frac{1}{2}$B and Zn
Nov. 19	38	7	5.7	3.3–10.1	Pf

was a specially pure sample furnished at our request. No great difference was noted in the effects of the two samples of thiazole. Thiamin and thiazole were added at the rate of 10 γ per flask. Solutions were steam steri-

lized under 10 or 15 lbs. pressure and the roots were grown in diffuse light at temperatures ranging from 20°C or somewhat less to a maximum of about 25°C.

Several mineral solutions were used. These included White's mineral solution, a modified Pfeffer's solution similar to that originally used by

TABLE 2

Growth of excised tomato roots in solutions of minerals, pure cane sugar and thiazole through 19 successive passages.

DATE	PASSAGE	NO. ROOTS WEIGHED	DRY WT. PER ROOT MG.	RANGE DRY WT. MG.	SOLUTION
1937					
Apr. 11	19	4	3.6	1.2– 8.2	Wh
May 8	20	4	13.7		Wh+B and Zn
June 9	21	2	24.6	23.8–25.5	Wh+B and Zn
July 16	22	2	12.9	11.7–14.1	Wh+B and Zn
Aug. 25	23	4	17.3	13.7–21.8	Wh+B and Zn
Sept. 27	24	4	23.1	14.3–32.9	Wh+B and Zn
Oct. 19	25	6	11.9	8.1–14.5	Wh+B and Zn
Nov. 15	26	7	12.6	0.4–28.9	Wh+B and Zn
1938					
Jan. 10	27	6	27.2	6.7–33.2	Pf+B and Zn
Jan. 10	27	3	19.8	13.2–25.0	Wh+B and Zn
Mar. 3	28	9	13.1	1.7–61.0	Wh+B and Zn
Apr. 12	29	8	12.0	0.8–25.0	Wh+½B and Zn
May 16	30	4	13.4	2.5–24.3	Wh+½B and Zn
June 14	31	2	13.6	11.0–16.3	Wh+½B and Zn
July 12	32	9	8.2	1.1–10.6	Wh
Aug. 3	33	10	8.4	4.9–14.5	Pf
Aug. 25	34	9	8.7	5.7–14.3	Pf
Sept. 15	35 Th_1	7	4.5	3.1– 6.3	Pf
Sept. 15	35 Th_2	7	4.0	2.6– 6.6	Pf
Sept. 15	35 Th_1	5	5.5	2.6– 9.1	Wh+½B and Zn
Sept. 15	35 Th_2	4	5.2	3.8– 6.7	Wh+½B and Zn
Oct. 18	36 Th_1	8	8.8	6.7–11.6	Pf
Oct. 18	36 Th_2	10	7.9	4.2–10.5	Pf
Oct. 18	36 Th_1	5	7.7	4.4–10.3	Pf+½B and Zn
Oct. 18	36 Th_2	5	9.1	7.1–11.9	Pf+½B and Zn
Nov. 19	37	3[1]	2.9	1.6– 4.1	Pf

[1] 4 of the best roots in this passage were used for inoculum.

Robbins (2) and the same solutions supplemented with 0.1 ppm B and 0.1 ppm Zn or 0.05 ppm B and 0.05 ppm Zn or an A to Z mixture (5) at one half strength. White's mineral solution contained per liter of distilled water $Ca(NO_3)_2$, 0.142 g.; $MgSO_4 \cdot 7H_2O$, 0.073 g.; KNO_3, 0.081 g.; KCl, 0.065 g., KH_2PO_4, 0.012 g.; $Fe_2(SO_4)_3$, 0.0024 g. The modified Pfeffer's

solution contained per liter $Ca(NO_3)_2$, 0.333 g.; $MgSO_4 \cdot 7H_2O$, 0.063 g.; KNO_3, 0.063 g.; KCl, 0.042 g.; KH_2PO_4 0.06 g.; $Fe_2(SO_4)_3$, 0.0025 g.

The growth in solutions containing thiamin is given in Table 1 and that in solutions containing thiazole in Table 2. The first column gives the date of addition of inoculum to the solutions; the second, the number of the passage since the seedling root was severed; the third, the number of roots weighed; the fourth, the average dry weight per root; the fifth, the range in the dry weights of individual roots and the last column, the special medium used. In the last column White's mineral solution is indicated by Wh, the modified Pfeffer's solution by Pf, 0.1 ppm B and 0.1 ppm Zn are indicated by B and Zn, 0.05 ppm Zn by $\frac{1}{2}$B and Zn and the A to Z mixture by Sol $Z\frac{1}{2}$. The first sample of thiazole is indicated by Th_1 and the second by Th_2.

As a rule the roots were grown for two months before dry weights were determined though on occasion they were grown for $2\frac{1}{2}$, 3 or even 4 months. There seemed to be little relation between the final dry weights and the length of the growth period; some of the heaviest roots grew but two months. Other factors were evidently more important than time in determining total growth.

The growth in passages 28, 29, 30 and 31 in the thiamin solution was slight and we assumed that this might indicate that a solution supplemented with thiamin alone was not adequate for continued growth. However, the roots returned to more nearly normal weights in passages from 32 to 38. Whether the poor growth in passages 28 to 31 was caused by temperature variations, differences in the mineral salts used or some other factor is uncertain. The minerals might be thought to be concerned because of the poorer results in White's mineral solution than in Pfeffer's solution (see passages 28, 30 and 31).

That the decreased growth in passages 28, 29, 30 and 31 was not an indication of "running out" is shown in figures 1 and 2. These figures show the fragment used for inoculum and the root which grew from it in the 21st successive passage in a solution of minerals, sugar and thiamin and the original inoculum and resulting root in the 15th successive passage in a solution of minerals, sugar and thiazole. The fuzziness of the roots in these photographs is in part due to the presence of root hairs.

The largest root in the thiamin solutions weighed 26.7 mg. (passage 20) and the highest average weight was 16.5 mg. (passage 21). In general the variability of the roots grown in the thiamin solutions was greater than those in the thiazole solutions.

The largest root in the thiazole solutions (61 mg.) was in passage 28. These roots grew 4 months which may account for the large size. In pas-

sage 24 the period of growth was 2 months and the largest root weighed 32.9 mg. The best average weight was 27.2 mg. in passage 27. Up to passage 31 the average dry weights were higher than those of later passages. This is in part accounted for by longer periods of growth in the earlier passages where many of the roots grew for 3 or 4 months before weights were taken. From passage 32 on the dry weights were determined after 2

Fig. 1. Photograph of excised root of tomato grown in Pfeffer's solution plus 2 per cent cane sugar and 10 γ of thiamin in Passage 34, the 21st successive passage in a solution of minerals, sugar and thiamin. The root fragment from which this root grew is shown by the drawing in the upper left hand corner. Age 7 weeks.

months growth. However, in passages 20, 23 and 24 the period of growth was 2 months; factors other than time are evidently important.

In general we have found the modified Pfeffer's solution preferable to White's mineral solution. Some of our results showed that the addition of boron and zinc was beneficial but later experiments made such a conclusion doubtful, especially when the boron and zinc were added to White's mineral solution. One of the major difficulties in such experiments is to

secure chemicals of uniform purity (or impurity) and since it was necessary to use different lots of mineral salts during the course of these experiments some of the variation in the results of successive experiments might have been caused by differences in the impurities present in different lots of mineral salts.

Fig. 2. Photograph of excised root of tomato grown in Pfeffer's solution plus 2 per cent cane sugar and 10 γ of vitamin thiazole in Passage 33, the 15th successive passage in a solution of minerals, sugar and thiazole. The root fragment from which this root grew is shown by the drawing in the upper left hand corner. Age 7 weeks.

No facilities for maintaining a constant temperature were available and variations in temperature also account in part for differences in growth in successive passages.

Furthermore, the best roots in each passage were used as sources of inoculum and were not included in the dry weights; the dry weights in all instances were, therefore, less than the maximum.

The roots grown in these solutions as a rule developed many branches of about equal size (see figures 1 and 2); that is, except occasionally in the

early stages of growth there was no dominating main root tip. Root hairs were freely produced and an occasional root which remained undisturbed became fastened firmly to the bottom of the flask by the root hairs. This was somewhat surprising in view of the smooth unscratched surface to which they became attached and was interpreted to mean that the walls of the root hairs were sufficiently gelatinous when first formed to stick to the glass.

One of the interesting observations from these data is that the growth in the solutions supplemented with thiazole was generally superior to that in solutions supplemented with thiamin. This was unexpected as we believe that the effective agent is thiamin, the tomato roots in the solutions supplemented with thiazole form vitamin pyrimidine (5) and we have assumed that thiamin is made by the tomato root from the two intermediates. It is possible that with a considerable excess of thiamin, as occurs in the solutions used in these experiments, sufficient pyrimidine was present to be injurious.

Another conclusion to be drawn from all these experiments is that amino acids are not essential for the growth of excised roots as might be concluded from the papers by Bonner and Addicott (1) and by White (9). The sole source of nitrogen available to these excised roots throughout the experiments was in the form of nitrates. It is clear from these results that this strain of tomato roots was capable of synthesizing its proteins from nitrates.

Although it would appear from these results that unlimited growth of this strain of tomato roots is possible in a solution of minerals, sugar and thiamin or in a solution of minerals, sugar and thiazole there is of course a possibility that the cane sugar used, in spite of its high purity, contained traces of another growth substance. In addition even though no growth occurs without thiamin or thiazole the rate of growth in the presence of these supplements is slow. The slowness of growth is because of the limited ability of the roots to synthesize adequate amounts of a second growth substance needed in their development. This second growth substance is vitamin B_6 (6, 7).

It should not be concluded from these results that the excised roots of other kinds of plants must be supplied with thiamin or thiazole and vitamin B_6 for successful growth in liquid cultures. Many growth substances are probably concerned in the development of a root. The roots of one kind of plant, the tomato for example, may be deficient in thiamin (or thiazole) and vitamine B_6. Those of another kind of plant may synthesize adequate amounts of one or both of these substances but lack the ability to make others. It is necessary, however, to make sure of our understand-

ing of the requirements of one root in order that the results may be intelligently applied to those of others.

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The Microfibrillar and Microcapillary Structure of the Cell Wall[1]

I. W. Bailey

(with 11 figures)

A detailed microscopic examination of different types of cells in various tissues and in a wide range of both gymnosperms and angiosperms reveals much diversity in the visible structure of cell walls. The commonest and most salient types of structural patterns[2] in secondary walls are (1) concentric layering or lamellation, (2) radial and ramifying lamellations, and (3) radio-concentric patterns, complex combinations of the two preceding types. The structural patterns of different cell walls fluctuate in texture from such as are relatively coarse and clearly visible under high magnifications to others that are invisible except in swollen preparations. When walls of the former type are carefully and gradually expanded, finer and finer details of structure become visible under the microscope without serious modification or distortion of the original structural design (Bailey and Kerr, 1935; Kerr, 1937; Bailey, 1938). In all cases, regardless of variations in texture, the cellulose resolves itself ultimately into a porous matrix composed of tenuous coalesced fibrils. In other words, the diverse structural patterns are due to varying densities or porosities in different parts of the cellulosic matrix (figs. 1 and 3). In the denser parts, the volume of the interfibrillar capillary spaces is reduced, and the fibrils are more numerous per unit area and are more extensively coalesced. Conversely, in the more porous parts, the volume of the capillary spaces is increased, and the fibrils are less closely approximated.

The specific and characteristic structural patterns seen in cell walls of the higher plants are not artifacts induced by swelling, *since they frequently are visible in unswollen walls*. Nor are they due to secondary changes or rearrangements occurring subsequent to the formation of the cell walls, since identical patterns are clearly visible in the developing walls of growing and differentiating cells. During the earlier stages of the formation of both primary and secondary walls,[3] it is possible to demonstrate, visually, that the cellulose is deposited in the form of coalescing fibrils of varying diameters and orientations (fig. 7). Furthermore, as Kerr (1937) and Anderson and Kerr (1938) have so clearly shown, the formation of alternat-

[1] Presented before Section G of the American Association for the Advancement of Science at Richmond, Virginia, Dec. 28, 1938.

[2] As seen in sections cut at right angles to the long axis of a cell.

[3] For a discussion of the distinction between primary and secondary walls see Kerr and Bailey (1934).

ing concentric lamellae of varying porosity is due, in the cotton hair, to fluctuating environmental factors; e.g., more porous lamellae are formed at night and denser ones during the daytime. Thus, the hairs of different cotton plants—grown during the same period of varying environmental influences—may exhibit identical patterns of lamellae, and it is possible to cross-date the *daily* growth rings, much as the *annual* rings in stems of western yellow pine may be cross-dated.

In the case of heavily lignified walls, the lignin may be removed, leaving a coherent matrix of cellulose; or conversely, the cellulose may be extracted, leaving a coherent residue of lignin (Bailey and Kerr, 1935; Bailey, 1938). The two types of residues are remarkably similar and are, in fact, positive and negative images of the same structural pattern (figs. 1 and 2). The pattern of the lignin residue may be interpolated within the porosities of the cellulosic matrix and *vice versa*. This demonstrates not only that the lignin is deposited within the interfibrillar capillary spaces of the cellulosic matrix, but also that the elongated interstices of the cellulose are intercommunicating (figs. 4 and 5). It is evident, accordingly, that in dealing with cell walls, we are concerned with two continuous interpenetrating systems, one of coalesced fibrils of cellulose and the other of interconnecting capillary spaces. The capillary system may be filled with water or may contain varying percentages of lignin, polyuronides, polyoses, tannins, phlobaphenes, terpenes, resins, and other complex organic compounds.

It should be noted in this connection, however, that not all the visible

Explanation of Figs. 1-5

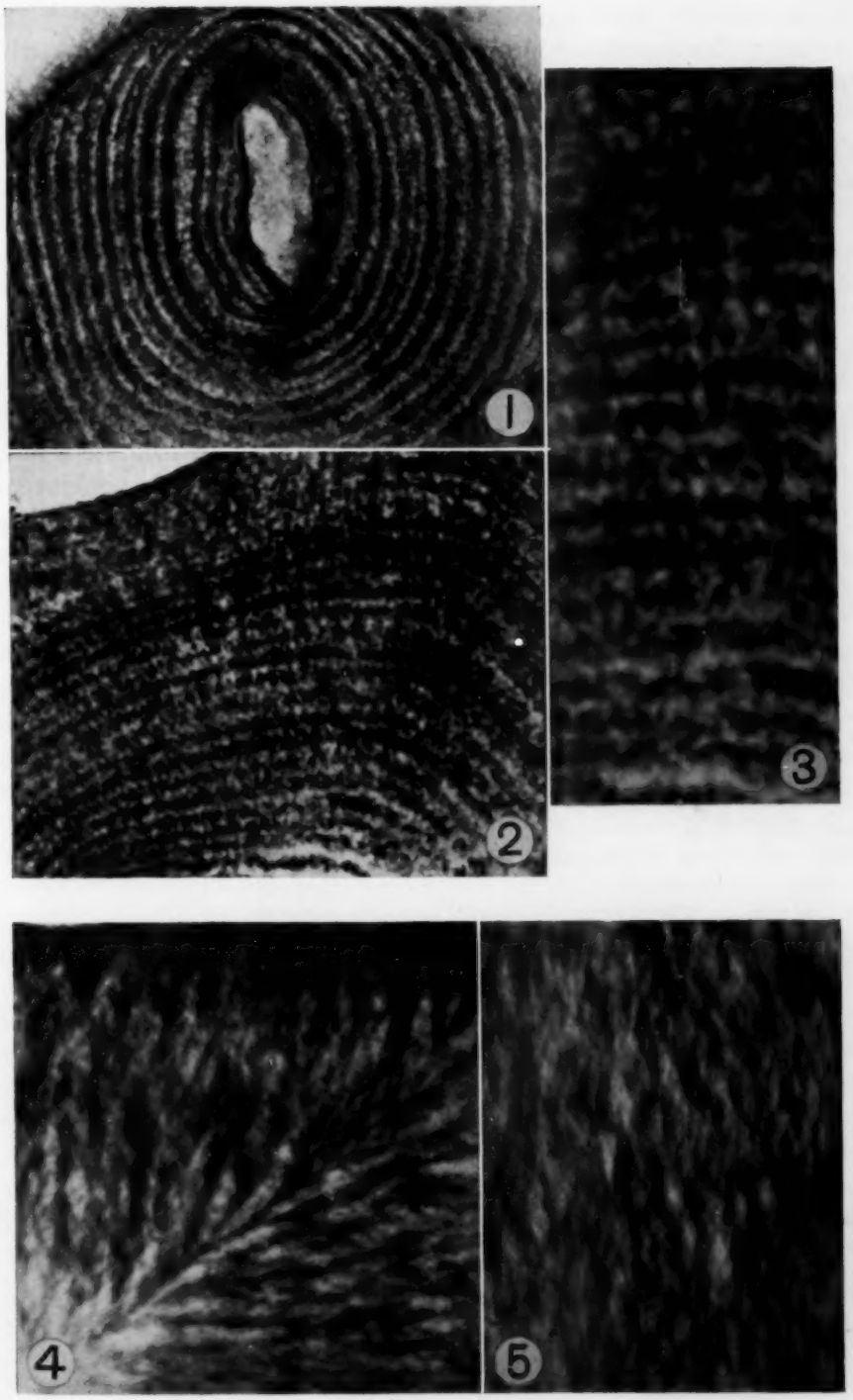
Fig. 1. Expanded transverse section of a concentrically lamellated secondary wall. The microfibrils of cellulose (dark) and the microcapillaries (light) are seen in cross section. In the denser lamellae, the microfibrils are more closely aggregated and more extensively coalesced than in the lighter, more porous lamellae. Total enlargement. ×7500.

Fig. 2. Coherent lignin residue from a structurally similar type of secondary wall. The microfibrils of lignin, which filled the microcapillaries illustrated in fig.1, are dark; whereas the porosities left by the removal of the cellulose are light. Figs. 1 and 2 are obviously positive and negative images of the same structural pattern, and the lignin residue may be interpolated within the porosities of the celllulosic matrix and vice versa. Total magnification. ×9000.

Fig. 3. Illustrates a portion of either fig. 1 or fig. 2 very highly magnified. The more or less closely aggregated fibrils are dark, the porosities are light. Total magnification. ×25,000.

Fig. 4. Expanded transverse section of a secondary wall, having a radio-ramifying structural pattern. Total magnification. ×5850.

Fig. 5. Expanded longitudinal section of such a wall, showing the coalesced microfibrils. Total enlargement. ×5850.



Figs. 1–5

structures of cell walls are due solely to variations in density or porosity of the cellulosic matrix. More or less conspicuous concentricities may be produced, at times, by varying amounts of lignin or of other substances that are deposited in different parts of the cell walls. Furthermore, actual discontinuities, due to the presence of non-cellulosic layers or lamellae, occur characteristically in the walls of certain specific types of cells (Bailey and Kerr, 1935),—e.g., tracheids of "Rotholz," so-called gelatinous fibers, sclereids, etc. In addition, most of the thicker types of walls exhibit concentric layers of varying indexes of refraction that are due primarily to different orientations of the microfibrils in successively-formed layers of the cell wall (Bailey and Vestal, 1937a). In other words, the microfibrils and the elongated microcapillaries may be oriented parallel to the long axis of the cell, at right angles to this axis or helically in relation to it (fig. 8).

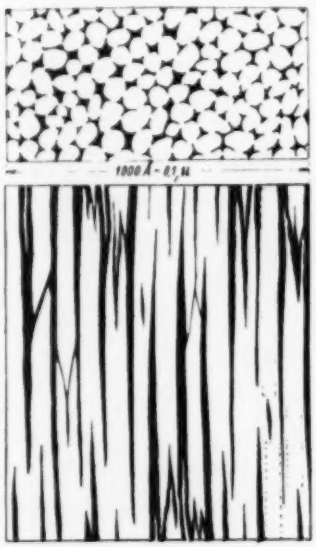


Fig. 6. Frey-Wyssling's conception of the submicroscopic structure of cellulose as viewed in transverse and longitudinal sections. The coalesced micelles (light) are separated laterally by intermicellar spaces (dark).

The evidence summarized in the preceding paragraphs indicates that, in the field of microscopically visible structures, cellulose is composed of a continuous system of coalesced microfibrils which is perforated by a continuous system of intercommunicating microcapillaries. It is of interest to compare the visible structure of cellulose with pictures of its structure postulated by workers in the submicroscopic field. For many years following the publication of Nägeli's micellar theory, the micelles or crystallites of cellulose were considered to be discrete entities separated on all sides by intermicellar spaces. Evidence obtained largely by X-ray analyses was interpreted as indicating that these micelles are composed of aggregations of chain molecules oriented parallel to one another with specific and characteristic spacings between the individual chains of the aggregation. More recently, Frey-Wyssling (1936, 1938), in order to harmonize the conflicting evidence from various fields of physical and chemical research, has profoundly modified this classical conception. As indicated in fig. 6, he now regards cellulose as a continuous matrix of overlapping chain-molecules which is perforated by a continuous system of intermicellar capillaries. In other words, micelles are no longer to be regarded

as discrete crystallites, but merely as anastomosing parts of a coherent porous matrix. There is much that can be said in favor of such a view, since it allows for chain-molecules of greater length, for the coherence of purified cellulose, and for various optical, physical, and chemical properties of cell walls in general. It should be recognized, however, that according to this modification of Nägeli's hypothesis, the crystallite loses its individuality and possibly should no longer be designated as a micelle.

Frey-Wyssling's modified conception of the submicroscopic structure of cellulose so closely resembles the finer visible structure of the cell wall that the question arises: Are there two distinct sizes of fibrils and of capillaries, or are there series of these structures that grade down in size to "micelles" and "intermicellar" spaces? Reliable factual data are not available, at present, for conclusively answering this question; but it is desirable to discuss certain aspects of the problem which may be significant in its clarification. A number of investigators maintain that lamellae are composed of a single layer of fibrils, and that the diameter of the fibrils and lamellae is constant. It is difficult, however, to homologize the constants obtained by different workers. For example, the diameter of fibrils is considered by some to be 4000 Å, by others 11,000 Å, and by others as much as 30,000–40,000 Å. That such *macrofibrils* are heterogeneous is indicated by their particle double refraction, by their dichroism, and by other optical and physical evidence. Furthermore, cellulosic primary walls frequently are less than one micron in thickness and obviously cannot be constituted of particles or fibrils 11,000 Å in diameter.

The approximate diameters of the finest lamellae and microfibrils that are visible in swollen walls may be determined by the following procedure.[4]

[4] It should be emphasized, in this connection, that if the expansion of the wall is not accurately controlled, the original structural pattern will be seriously modified or destroyed, and various artifacts may be produced. Thus, it is essential to avoid (1) degrading the cellulose by oxidation or hydrolysis and dissecting the wall into fusiform bodies and other small fragments before swelling occurs; (2) dissociating the aggregated microfibrils by excessive or unduly rapid expansion and dissecting them into minute particles; and (3) precipitating dispersed cellulose in the form of granules. Where the process of swelling is skillfully controlled, the highly specific and characteristic structural pattern—whether concentric, radial, ramifying, or radio-concentric of a particular type of cell wall is retained and expanded. This is true regardless of the plane of sectioning of the cell, whether transverse, longitudinal, or diagonal. A small fragment of the wall exhibits its own characteristic part of the particular structural pattern from which it was removed. The argument that the structural patterns are artifacts due to pressure during swelling, is thoroughly invalidated by the fact that the characteristic patterns frequently are visible in unswollen sections and persist during swelling, regardless of whether the sections are pressed under a cover glass or not.

The diameter of a wall in its unswollen condition is accurately measured. The wall is then expanded, and the number of its constituent lamellae is counted. If the wall is X units in diameter and is composed of Y lamellae, the average diameter of the lamellae in the unexpanded wall must be X/Y. By the use of this procedure it is possible to determine that the width of the finest lamellae is 500 Å or less. The diameter of the microfibrils also is 500 Å or less, since the narrowest lamellae are composed of a single layer of fibrils and the wider ones of more than one layer. The visible expanded microfibrils fluctuate somewhat in size, but it is not possible, at present, to determine whether this is due to inequalities in swelling or solely to inherent differences in diameter of the unexpanded microfibrils. Furthermore, since the microfibrils are not visible in their unswollen state, it is not possible to study their optical anisotrophy or their dichroism except in a condition where the spacing of their constituent chain-molecules may have been modified. The microcapillaries commonly are less than 500 Å in diameter, but there are no reliable data available for determining their exact dimensions or for demonstrating whether they are of constant or of fluctuating cross-sectional area. Measurements obtained from lignin residues are unreliable, since the microcapillaries of the cellulosic matrix may have been enlarged by the infiltrating lignin; there is said to be some swelling of walls during lignification. Similarly, there is a considerable element of uncertainty in attempting to compute the diameters of the microcapillaries by measuring the diameters of crystals that may be deposited within them (Frey-Wyssling, 1937a; 1937b). For, on the one hand, the diameter of the crystals may be less than that of the microcapillaries, and, on the other hand, it may be greater; viz., where the crystals enlarge the microcapillaries by crowding the microfibrils apart (fig. 8). That the latter phenomenon actually occurs may be observed in cases where the crystals or crystal aggregates enlarge to visible dimensions (Bailey and Vestal, 1937a; Frey-Wyssling, 1937b). Nor is it safe to assume that the so-called micelle is of constant dimensions. The much quoted values of 500–750×50–60 Å were obtained from X-ray analyses of a specific type of cell wall,—i.e., that of ramie fibers (Hengstenberg and Mark, 1928). Even if the calculations were based upon thoroughly reliable assumptions, which is by no means certain, such measurements cannot be accepted as constants until a number of diverse types of cell walls have been analyzed.

In view of such facts as these, the present status of available information regarding the structure of the cellulosic wall of the higher plants may be summarized briefly as follows:

Chemical and physical research indicates that cellulose is composed fundamentally of more or less elongated chains of anhydrous glucose

residues. These chain-molecules tend to occur in aggregations within which they are arranged parallel to one another with characteristic spacings between the individual chains. In addition, there is evidence which suggests that the aggregations of chain-molecules are not discrete and separate entities, but that they are parts of a continuous system, which is held together by overlapping chain-molecules and is perforated by a continuous system of "intermicellar" spaces.

Similarly, in the field of microscopically visible structures, the cellulosic matrix appears to be a continuous system composed of coalesced microfibrils which grade down to 500 Å or less in diameter (Freudenberg, 1932; Bailey, 1938). The matrix is perforated by a continuous system of interconnected microcapillary spaces which may be filled with water or with lignin and a wide variety of other organic compounds. The visible structural patterns of both primary and secondary walls are due—except in certain specific types of cells—primarily (1) to variations in the density or porosity of the cellulosic matrix; (2) to different types or percentages of non-cellulosic substances that are deposited within the microcapillaries; or (3) to changes in the orientation of the microfibrils and microcapillaries in successively-formed layers of the cell wall.

Although the evidence from both the microscopic and the sub-microscopic fields of research indicates that the cellulosic matrix of cell walls is a continuous rather than a discontinuous system, there is a dearth of reliable information regarding structural details which may intervene between the unit cell and 500 Å. There appear to be no reliable data available, at present, for determining whether microfibrils are of constant or of fluctuating diameter, whether they are heterogeneous and composed of still finer coalescing fibrils, or whether they are constituted directly and solely of anastomosing "micelles"; similarly, whether there are two distinct sizes of capillary spaces, or whether the microcapillaries and the "intermicellar" spaces are connected by interstices of intermediate or transitional sizes. It is essential to clarify such uncertainties as these, since it is structures in this general field of magnitudes, 10–500 Å, that are likely to be of considerable significance, not only in the solution of various problems in the economic utilization of pulp and of cellulose and its derivatives, but also in the elucidation of a number of obscure physiological processes.

It should not be inferred from this, however, that many of the properties of cell walls can not be accounted for upon the basis of available data. For example, many of the conspicuous differences in the optical and mechanical properties of cell walls and wall layers are closely correlated with variations in the orientation of the microfibrils and microcapillaries. Walls

or layers composed of microfibrils which are oriented parallel to the long axis of the cell are isotropic in transverse sections and do not contract longitudinally in drying; whereas walls having transversely oriented microfibrils are strongly birefringent in cross sections and contract longitudinally in drying. Various intermediate conditions occur in walls whose microfibrils are oriented helically in relation to the long axis of the cell. Although the two types of physical anisotropy are due, fundamentally, to the arrangement of aggregates of chain-molecules, the microfibrils may be utilized as indicators, since the long axis of the chain-molecules and of the "micelles" is oriented parallel to that of the microfibrils.

It should be emphasized, in this connection, that there is a considerable element of uncertainty in attempting to account for the optical and other physical properties of specific types of cell walls solely upon the basis of putative "micellar" arrangements, without regard to the microfibrillar orientations. Thus, a wall may be isotropic in surface view, not because the "micelles" are randomly oriented throughout it, but because the microfibrils in its successively-formed layers are variously oriented. In other words, the chain-molecules and "micelles" have a preferred orientation—parallel to the long axis of the microfibrils—in each layer, but where the layers are of relatively uniform thickness the wall may exhibit isotropy in surface view. Furthermore, walls of this character may give a ring-type of X-ray diffraction pattern which is commonly interpreted as an indication of a truly random orientation of crystallites. It is such phenomena as these which have led to various misconceptions regarding the structure of primary walls and concerning changes that occur during their increase in surface area. In fact, in studying the growth and expansion of primary walls, attention may profitably be focused upon visible adjustments and rearrangements in the microfibrillar and microcapillary systems rather than solely upon postulated changes in the "micellar" system. The extinction angles of individual macrofibrils in monochromatic polarized light usually are clearly and sharply defined, whereas those of the cell wall as a whole may be vague and indefinite. The latter condition commonly is due, not to "scattering" or deviations in the alignment of adjacent "micelles," but rather to fluctuations in the orientation of the fibrils. The optical anisotropy of the fibrils of native cellulose appears to be *positive* in all cases, and the so-called positive and negative birefringences of cell walls is determined by the orientations of the fibrils in relation to the long axis of the cell. There is no reliable evidence, at present, to indicate that the structural framework of the plant cell wall ever is composed of randomly oriented cellulose. In all the various structural types of cells that I have

examined, the cellulose exhibits a preferred orientation in each of the tenuous, successively-formed parts of the cell wall.

The enzymatic hydrolysis of cellulosic walls (fig. 9), due to the activity of certain wood-destroying fungi, progresses along two predetermined sets of planes (Bailey and Vestal, 1937b), as does the acetylation of cellulose. One of these sets of planes is oriented parallel to the long axis of the microfibrils and *pari passu* of the microcapillaries, "micelles," and chain-molecules. The other is oriented at an angle of from 20–25 degrees to this axis. The latter set of planes of hydrolysis and of chemical reaction is not correlated with any visible structure of the cellulosic matrix, but it does correspond rather closely—as the computations[5] of my colleague, Professor Thimann, have shown—with certain spacings within the crystal-lattice of cellulose. These spacings are between the easily hydrolyzable ether-linkages of the cube-center and cube-side chains. They fluctuate around $14 \pm$ Å, and form planes which interesect the long axis of the chain-molecules at angles of from 22°40′ to 25°04′. Although the submicroscopic and the visible planes are oriented at similar angles, it is not evident why the chemical reactions should progress along these specific planes. If it be assumed that the spacing between the ether-linkages is of the most favorable magnitude for the insertion and activities of enzyme molecules, it is not clear why the reactions due to acetylation or to hydrolysis by phosphoric or sulphuric acids—where smaller molecules are concerned should progress along the same planes. Nor is it evident why the enzymatic hydrolysis should progress so commonly along a single plane rather than in a zigzag manner, since at any specific ether-linkage, it would seem that hydrolysis might progress in various directions, either upward or downward, at angles of from 22–25 degrees. Therefore, the most that may be concluded, at present, is that there are specific predetermined planes of chemical reaction in native cellulose, certain of which are closely correlated with visible orientations in the cellulosic matrix and others which must be due solely to molecular configurations.

Similarly, in the case of mechanically-induced cracking of the cell wall, (figs. 10 and 11) there are predetermined planes of cleavage, certain of which may be correlated with visible weaknesses of the cellulosic matrix and others that are due to submicroscopic factors. One of these sets of planes of structural weakness is oriented parallel to the long axis of the microcapillaries and microfibrils and is much accentuated in cell walls

[5] These computations were made in 1937, but were not published, owing to uncertainties in their interpretation. They are in substantial agreement, however, with those recently published by Frey-Wyssling (1938).

having concentric or radial lamellae of strikingly different porosities or densities. Such walls tend to split concentrically, radio-longitudinally, or radio-helically, even in ordinary drying; whereas walls of more uniform texture or of ramifying patterns do not. Failures, due to excessive compression, tension, torsion, etc., are of three distinct types: (1) oriented parallel to the long axis of the microfibrils and microcapillaries, (2) oriented approximately at right angles to this axis, or (3) of inconstant orientations. The so-called slip-planes, which have attracted so much attention in the literature, usually are discussed and figured as seen in sectional views of relatively thick secondary walls. The inclinations of these planes of buckling fluctuate over a range of nearly 90 degrees and are determined largely by the orientation of stresses and strains operative in their production. On the contrary, in surface views of cell walls, or of their constituent layers, the planes of buckling frequently are oriented nearly at right angles to the long axis of the microfibrils and microcapillaries. Since there are no visible structural weaknesses in this predetermined plane of buckling, it must be due to submicroscopic factors.

It should be emphasized in conclusion that, owing to the presence of predetermined planes of cleavage and of chemical reaction, the continuous cellulosic system of the cell wall may be dissected into fragments of varying forms and sizes,—e.g., dermatosomes, ellipsoid particles, fusiform bodies, macrofibrils, lamellae, layers, etc. The shape and the dimensions of such fragments are dependent upon the type of wall under consideration and upon the specific mechanical and chemical treatments to which it is subjected.

Explanation of Figs. 7-11

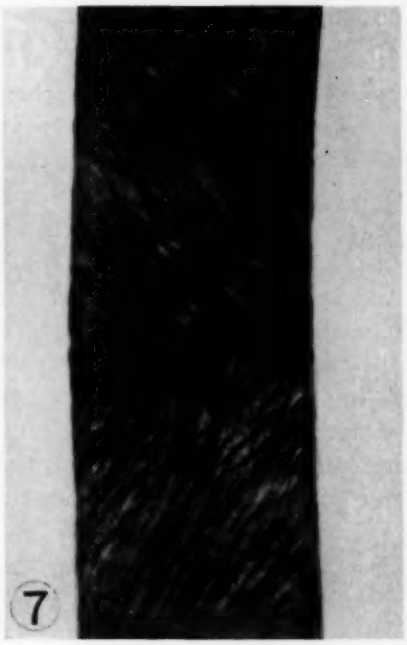
Fig. 7. Early stage in the formation of the secondary wall of cotton, showing coalescing fibrils and a "reversal" in their orientation. ×900. Photo by Dr. Thomas Kerr.

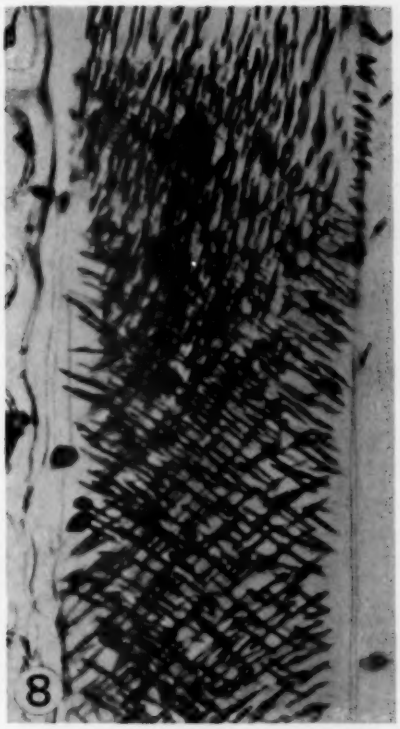
Fig. 8. Longitudinal section through parts of the secondary walls of two adjacent tracheids, showing three orientations of visible crystals of iodine. The crystals may be utilized in determining the orientation of the microcapillaries in the three layers of secondary wall, but they have enlarged the microcapillaries by crowding the microfibrils apart. ×900.

Fig. 9. Longitudinal section of a secondary wall, photographed in polarized light between crossed Nicols, showing cavities produced by wood-destroying fungus. There are two sets of planes of enzymatic hydrolysis, one oriented parallel to the long axis of the microfibrils and the other at an angle of from 20–25° to this axis. ×990.

Fig. 10. Longitudinal section of a secondary wall, photographed in polarized light between crossed Nicols, showing two planes of mechanical cleavage. ×700.

Fig. 11. The same. ×700.





Figs. 7–11

SUMMARY AND CONCLUSIONS

The cellulosic matrix, of the cell walls of the higher plants, appears to be a continuous rather than a discontinuous system. Physical and chemical data suggest that it is composed, in the submicroscopic field, of aggregations of chain-molecules that are held together by overlapping chain-molecules. In the microscopically visible field, it is constituted of coalesced microfibrils. In both fields of magnitude, the continuous cellulosic system is perforated by a continuous system of interconnecting capillary spaces.

The diverse structual patterns of varying texture, that are visible in both unswollen and expanded cell walls, are due in most cases (1) to variations in the number and proximity of the microfibrils and microcapillaries —i.e., variations in density or porosity—in different parts of the cellulosic matrix; (2) to different types or percentages of non-cellulosic substances that are deposited within the microcapillaries; or (3) to changes in the orientation of the microfibrils and microcapillaries in successively-formed layers of the cell walls.

The long axis of the chain-molecules and of the anastomosing "micelles" is oriented parallel to the long axis of the fibrils which exhibit positive anisotropy and sharply defined extinction angles in monochromatic polarized light. The vague and indefinite extinction angles of certain types of cell walls are due, apparently, not to deviations in the orientation of adjacent "micelles," but to fluctuations in the orientation of the fibrils. Similarly, isotropy in the surface view of cell walls and ring-types of X-ray diffraction patterns are not indicative, necessarily, of truly random orientation. The phenomena appear to be due to the fact that, although the cellulose has a preferred orientation in each set of microfibrils, the arrangement of the microfibrils fluctuates in the successively-formed tenuous lamellae of the wall. In fact, there is no reliable evidence, at present, to indicate that the structural framework of the cell wall ever is composed of randomly oriented cellulose.

There are predetermined planes of chemical reaction and of mechanical cleavage in the cell wall. Certain of these are closely correlated with visible structures, whereas others must be due to molecular configurations. Although the cellulosic matrix is a continuous system, it may be dissected into fragments of varying shapes and sizes by drastic mechanical and chemical treatments.

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Pollen Analysis of a Bog near Spokane, Washington

HENRY P. HANSEN

(WITH ONE FIGURE)

Postglacial forest succession in eastern Washington has been interpreted from pollen analysis of a bog about twenty miles northeast of Spokane. The bog lies at an elevation of 2100 feet, in T. 26 N., R. 45 E., SECT. 11 on the Spokane Quadrangle. The peat deposit, which covers about a section in area, is situated at the southern end of Newman Lake. Much of it is now used for growing wheat. The depth of the peat is 7.3 meters, and it is uniform in thickness over much of its area. A layer of volcanic ash occurs from the 4.7 to the 4.4 meter levels, a thickness considerable greater than that usually found in bogs of the Pacific Northwest (Hansen 1938, Rigg 1938). This may have been due to the heavy rains which generally follow volcanic eruptions, transporting the ash into the lake.

The lower meter of peat consists of a gray-brown sedimentary type overlaying sand. This grades upward into fibrous sedge peat, with the ash above separated by a sharp line of demarcation. Immediately above the ash again occurs sedimentary peat which indicates inundation of the bog at this time, suggesting that abnormally heavy rains followed the volcanic eruption. The sedimentary peat grades into fibrous sedge peat toward the surface.

Near the shore of the lake exists a floating plant hydrosere followed on land by zones of cattail, bulrush, sedge, and rush.

The peat samples were taken with a Hiller borer at half-meter intervals, at a distance of about 500 feet inland from the shore of the lake. The peat is fresh and unoxidized throughout its entire depth.

For study, the peat was deflocculated by boiling in a weak solution of potassium hydrate, washed several times, centrifuged, stained with gentian violet, and mounted in glycerin jelly. Three hundred pollen grains were identified from each level.

AGE AND ORIGIN OF THE BOG

The bog and lake are situated near the mouth of a small tributary system which formerly drained into the Spokane River valley a few miles to the south. This area was covered by the Spokane glaciation, which has been correlated with the pre-Wisconsin by some geologists (Bretz 1923, Leverett 1917). Flint (1937) finds no evidence of pre-Wisconsin glaciation, and considers the so-called Spokane glacier in this part of Washington to be of Wisconsin age. During the recession of the ice, the Spokane River aggraded its valley with glaciofluviatile sediments and caused

blockades at the mouths of many of its tributaries (Flint 1936). This resulted in the ponding of Newman Lake basin and the subsequent development of the bog. Bogs in the driftless area of Wisconsin, situated in the valleys of tributaries of the Mississippi and Wisconsin Rivers, have a similar origin (Hansen 1933). Thus the bog came into existence at the close of the Wisconsin glaciation, and probably records the forest succession which has occurred in adjacent areas during most of post-Wisconsin time.

FORESTS IN ADJACENT AREAS

The bog lies within the timbered Arid Transition zone as defined by Merriam (1898). Spokane has a mean annual precipitation of about 18 inches. Forest-type maps show a western yellow pine (*Pinus ponderosa*) type covering much of the adjacent areas. The treeless Arid Transition zone exists a few miles to the south and west. At higher elevations to the north and east, yellow pine is replaced to some extent by more montane types, of which western white pine (*Pinus monticola*) is the commonest. Other species include Douglas fir (*Pseudotsuga mucronata*), western larch (*Larix occidentalis*), western hemlock (*Tsuga heterophylla*), white fir (*Abies grandis*), western red cedar (*Thuja plicata*), and lodgepole pine (*Pinus contorta*). The latter is also common on terraces along the Spokane River where it forms dense, pure stands. At still higher elevations on north exposures and damper sites, Englemann spruce (*Picea engelmanni*), mountain hemlock (*Tsuga mertensiana*), and subalpine fir (*Abies lasiocarpa*), are present.

FOREST SUCCESSION

The first forests to invade this area in postglacial time consisted of lodgepole and white pines, and western larch. These show pollen frequencies of 34, 15, and 23 per cent respectively, in the lowest level (fig. 1). The dominance of this forest is recorded to the 6 meter level, from which white pine and larch decrease rapidly and lodgepole pine less so. The pollen curves of these species correlate with their relative tolerance for shade, lodgepole being the most intolerant, followed by larch and white pine (Larsen 1930). Lodgepole is the first to decrease, while larch and white pine still increase, then larch begins to decrease while white pine still increases and finally decreases. No yellow pine pollen is recorded in the lower two levels, but it has frequencies of 2 and 5 per cent at the 6.5 and 6 meter levels.

The decrease of these pioneer forests and the sharp increases of grass, chenopods, and composites which are shown in the diagram, indicates the initiation of a warmer and dryer climate occurring during the deposition

of peat between the 5.5 and 4 meter levels. At the 5.5 and 5 meter levels grass pollen has frequencies of 38 and 25 per cent respectively. A heavy influx of grass during this period marks the extension of the treeless Arid Transition zone into areas near the bog. This life zone is at present characterized by grasses, including bunchgrass (*Agropyron spicatum*) and June grass (*Poa sandbergii*), and by the composite, balsam root (*Balsamorhiza sagittata*), in eastern Washington (Piper 1906). As increased dryness apparently continued the Upper Sonoran life zone became more widespread. Characteristic species of this zone include such composites as sagebrush (*Artemisia tridentata*) and rabbit brush (*Chrysothamnus nauseosus*), and the chenopods, hop sage (*Grayia spinosa*), greasewood (*Sarcobatus vermiculatus*), and saltbush (*Atriplex argentea*). The pollen count at the 4.5 meter level shows 15 per cent for the former and 16 per cent for the latter (fig. 1). The chenopods thrive under more saline conditions than the composites, but it would be difficult to say if and how salinity played any part at this time. It is to be noted that the volcanic eruption recorded by the ash, occurred near the close of grass-chenopod-composite dominance. The Upper Sonoran zone at present is confined chiefly to south-central Washington, but it extends up the Columbia and Spokane River valleys, and in the latter it reaches to within a distance of twenty-five miles west of Spokane (Piper 1906). It is likely that the flora of this zone formerly existed farther up the Spokane River Valley and was sufficiently close to be recorded by pollen in the bog.

The termination of the xerothermic period is marked by increases in larch, and yellow, white, and lodgepole pines. Larch assumes the more aggressive aspect with 20 per cent at 4 meters, but from this point it shows a constant decrease to the surface. Lodgepole pine steadily increases to 23 per cent at 2.5 meters, white pine to 23 per cent at 1 meter, and yellow pine increases sharply to 42 per cent at 2 meters. This period apparently was one of increasing coolness and moisture, with a mixed forest of these four species, and yellow pine assuming the dominant rôle. Other trees, indicated by low pollen percentages during this period, include western hemlock, Douglas fir, white fir, and Englemann spruce.

A final period, recorded from 2 meters to the surface, is marked by the existence of a western yellow pine climax, which has persisted in this area to the present day. The presence of white and lodgepole pines with 18 and 8 per cent at the top, indicates their proximity to the bog now. The former is scattered throughout the forest in adjacent montane areas, and the latter exists in pure stands where the forest has been removed by lumbering or fire. An increase of grass from 4 per cent at 0.5 meter to 15 per cent at the top may also be explained by the removal of the forest cover in recent

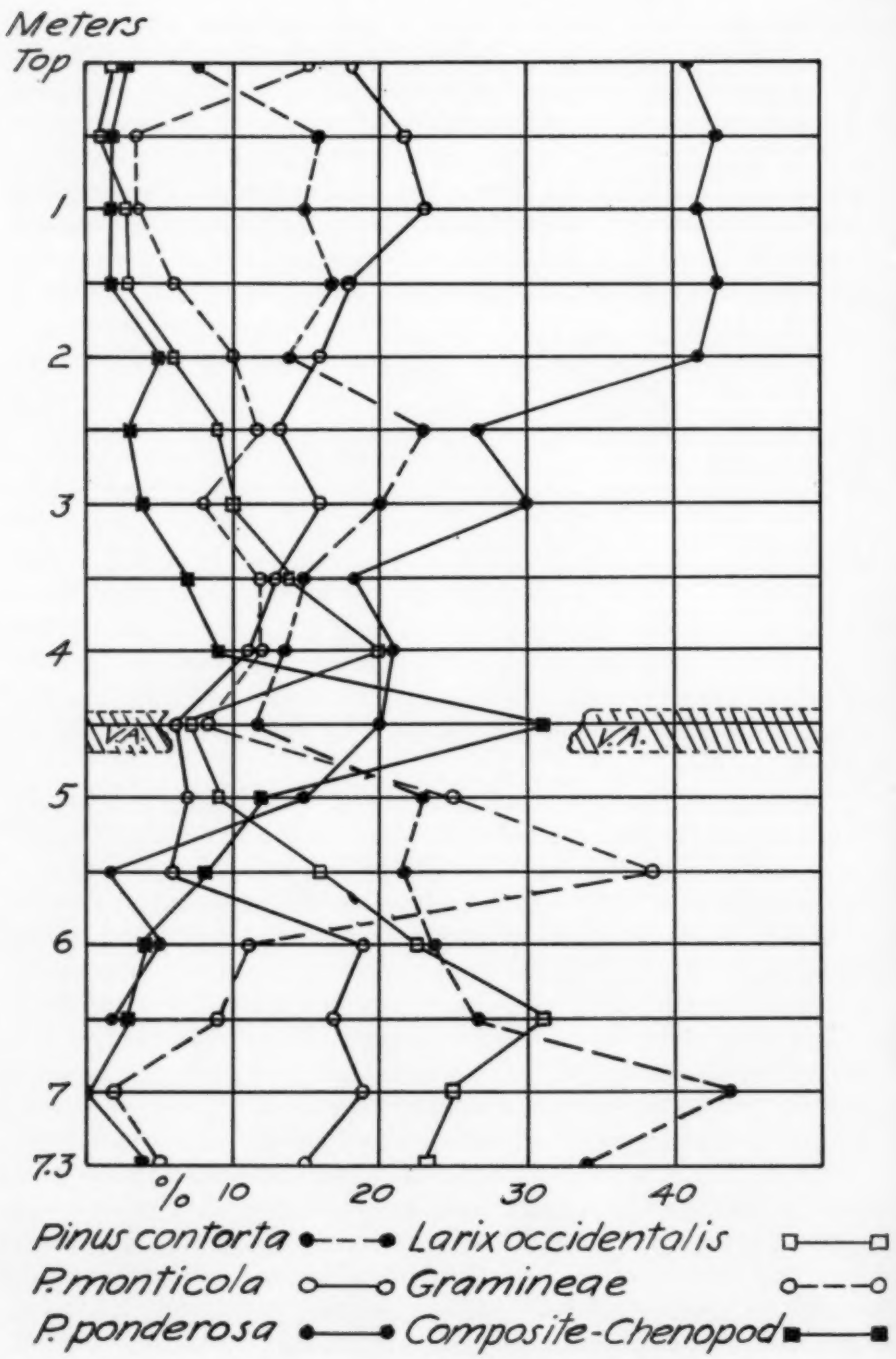

Fig. 1. Pollen diagram.

times by man. The existence of other conifers in the area at present is to be noted by their low percentages in the upper most level (table 1). An abundance of maple (*Acer glabrum*) apparently existed near the bog during its early development, but became less abundant during postglacial time. Alder, willow, and birch were also present to some extent (table 1). Douglas fir and western hemlock played an inconspicuous rôle in postglacial forest succession in this area. The climate was evidently too dry, because these two species were dominant during most of postglacial time in the Puget Sound region (Hansen 1938). The tolerance of evergreens for shade is an important factor, and forest succession in the Northwest may be dependent upon their relative tolerance as much as climate.

TABLE 1

Principal pollens

DEPTH IN METERS	7.3	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	0.5	Top
Pinus contorta	34	44	27	24	22	23	12	14	15	20	23	14	17	15	16	8
P. ponderosa			2	5	2	15	20	21	18	30	27	42	43	42	43	41
P. monticola	15	19	17	19	6	7	6	11	13	16	13	16	18	23	22	18
Pseudotsuga mucronata			1	2	1	2	1	2	2	2	4	1	2	2	3	3
Larix occidentalis	23	25	31	23	16	9	7	20	14	10	9	6	3	3	1	2
Abies grandis	2	1						3	3	1	1	1	1	2	4	2
Picea engelmanni	7	2	1			1	1	1	1	2	1		1	1	1	
Tsuga heterophylla				1		1	1	1					1	1	1	1
Gramineae	5	2	9	11	38	25	8	12	12	8	12	10	6	4	4	15
Compositae	2		2	2	4	2	15	5	3	2	3	3	1	2	1	1
Chenopodiaceae	2		1	2	4	10	16	4	4	2		2	1	1	1	2
Alnus	9	5	8	10	2	4	7	5	8	3	6	6	3	3	2	4
Salix	1		1		1	1	4	1	5	1	1		1		1	1
Acer*	56	12	12	16	21	22	60	30	30	18	8	7	9	1	1	1
Betula*	1				2	1		5	2	5	13	2	7	6	1	2
Nymphaea*			3	15	26	1			1	9	9	2		1		1

* Number, not computed in the percentages.

SUMMARY

Pollen analysis of a post-Wisconsin bog in Northeastern Washington in a western yellow pine climax, shows several stages of postglacial forest succession and climate.

A pioneer forest consisting chiefly of lodgepole and western white pines and western larch, with a preponderance of the former, indicates an initial cool and medium dry period.

The first period was followed by one of increasing warmth and dryness, resulting in an extension of the treeless Arid Transition zone, as evidenced by a preponderance of grass pollen at 5.5 meters.

The next period was one of further drying and warming, causing an

extension of the Upper Sonoran zone, as shown by the high percentages of chenopods and composites at 4.5 meters.

The xerothermic period was succeeded by one of increasing coolness and moisture, which brought favorable conditions for the increase of yellow, white, and lodgepole pine forests.

A final period of coolness and medium dryness has existed during the time represented from the 2.0 meter level to the surface or present time. This period was characterized by a climax forest of western yellow pine, with some lodgepole and white pine, and other conifers, and was probably warmer than the initial period.

The author expresses his thanks to Mr. C. M. Chapman, Chief Scientific Aid, and Mr. Virgil Moss, Forester, of the U. S. Bureau of Entomology and Plant Quarantine, Spokane, Washington, for their assistance in obtaining the peat samples.

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Mosses of Interior British Guiana

EDWIN B. BARTRAM
(WITH TWO FIGURES)

The mosses in the following schedule were collected by Dr. A. C. Smith in central and southern British Guiana under the auspices of the New York Botanical Garden, the Arnold Arboretum and the Yale School of Forestry, together with the American Museum of Natural History Terry-Holden Expedition.

This previously essentially unexplored country, projecting like a tongue into the State of Para, Brazil, almost to the equator, might naturally be expected to support a moss flora closely resembling that of the Amazonian regions, but instead, a considerable number of the species represented in Dr. Smith's collections are decidedly more suggestive of the Caribbean mosses in a broad sense. This is particularly true of the highlands in the Kanuku and Akarai Mountains with elevations up to 900 meters.

Of the forty-eight species detailed below seventeen, or more than one-third of the total, range north to Florida, and twenty-five, or slightly more than half, are not represented in Mr. Richard's list published in 1934.[1] Ninety-one species including the Sphagna are credited to British Guiana in these two lists, evidently considerably less than the actual moss flora that may be reasonably expected even from such a comparatively limited area.

Where not indicated to the contrary the collections cited are from British Guiana. The types of the new species described are in the writer's herbarium and duplicates are in the herbarium of the New York Botanical Garden. I am indebted to the kindness of Mr. R. S. Williams for the loan of specimens from the New York Botanical Garden for comparative study.

FISSIDENTACEAE

Fissidens radicans Mont. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, alt. 700 m. *3325*.

Distribution: Florida, Mexico, Guatemala, Puerto Rico.

DICRANACEAE

Campylopus savannarum C. M. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, open rocky summit, alt. 975 m., *3645*, abundant on rocks; *3656*, among roots of *Doryopteris*.

Distribution: Costa Rica, Surinam.

[1] Richards, P. W. Musci collected by the Oxford Expedition to British Guiana in 1929. Kew Bull. **1934:** 317–337. 1934.

Holomitrium arboreum Mitt. Northern slope of Akarai Mountains, in drainage of Shodikar Creek, (Essequibo tributary), dense forest, on tree trunk, alt. 300–600 m., *2917*.

Distribution: Mexico to Bolivia, cordilleran.

Leucoloma serrulatum Brid. Northwest portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on tree trunks, alt. 650–850 m., *3600a*, *3614*, *3615a*.

Distribution: Antilles, Mexico to Costa Rica.

Leucoloma tortellum (Mitt.) Jaeg. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on rocks, alt. 250 m., *3118*. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on rocks along stream, alt. 650 m., *3673*.

As far as I know neither *L. serrulatum* nor *L. tortellum* have been recorded from South America before. The following sporophyte characters are taken from *3673* in which the capsules are all deoperculate and rather old. Perichaetial leaves slightly longer than the stem leaves, abruptly narrowed from a broad, short, clasping base to a slender, linear point, serrulate near the apex and unbordered. Seta erect, smooth, dark red, scarcely 1 cm. long; capsule erect, cylindric, urn about 2 mm. long; peristome teeth reddish, faintly papillose below (capsules overripe, peristome teeth worn and eroded); spores greenish, papillose, 15–20 μ. Probably dioicous, antheridial flowers not seen.

LEUCOBRYACEAE

Octoblepharum albidum Hedw. Basin of Rupununi River, Isherton, lat. about 2°20′N., on bark of *Curatella americana*, savanna, *2510*. Western extremity of Kanuku Mountains, in drainage of Takutu River, alt. 700 m., on charred tree trunks, *3311*. Northwestern slope of Kanuku Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on palm trunk, alt. 150–400 m., *3566*. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on tree trunks, alt. 650 m., *3676*.

Distribution: Cosmopolitan in tropical regions, north to Florida.

Octoblepharum cylindricum Schp. Basin of Kuyuwini River (Essequibo tributary), about 150 miles from mouth, dense forest, on tree trunks, *2603*.

Distribution: Mexico, Colombia, Brazil.

Leucobryum Martianum (Hornsch.) Hampe. Basin of Essequibo River, near mouth of Onoro Creek, lat. about 1°35′N., dense forest, on fallen log, on high land, *2706a*. Brazil: State of Para: southern slope of Akarai Mountains, in drainage of Rio Mapuera (Trombetas tributary), dense forest, on decayed log, alt. 500–700 m., *2929*, *2951a*.

Distribution: Antilles and Northern South America.

CALYMPERACEAE

Syrrhopodon prolifer Schwaegr. Brazil: State of Para: southern slope of Akarai Mountains, in drainage of Rio Mapuera (Trombetas tributary), dense forest, on decaying wood, alt. 500–700 m., *2951.*

Distribution: Colombia, Brazil.

Syrrhopodon ligulatus (Mont.) Mitt. Western Extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on charred tree trunks, alt. 700 m., *3311a.*

Distribution: Florida, Guadeloupe.

Syrrhopodon rigidus Hook. & Grev. Basin of Kuyuwini River (Essequibo tributary), about 150 miles from mouth, dense forest, on tree trunks, *2603a.*

Distribution: Antilles to northern Brazil.

Syrrhopodon incompletus Schwaegr. Northwestern slope of Kanuku Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on palm trunk, alt. 150–400 m., *3565.*

Distribution: Florida to northern South America, Mexico and Central America.

Calymperes Richardi C. M. Basin of Rupununi River, near mouth of Charwair Creek, lat. about 2°35′N., on fallen tree, forest, *2339.*

Distribution: Florida to Brazil, Mexico and Central America.

Calymperes (*Stenocycla*) **Smithii** sp. nov. (fig. 1). Olivaceum, laxe gregarium. Caulis circa 1 cm altus. Folia patentia. 3–3.5 mm. longa, e basi brevi latissime obcuneata, abrupte oblongo-ovata, acuta; marginibus medio folio minute denticulatis, prope apicem serratis; cellulae rotundatae, 8–10 μ, convexae, haud incrassatae, subpellucidae; costa valida, inferne laevis, superne papillosa, prope apicem dorso serrata, cum apice soluta; cancellina breviter obovata, apice rotundata, 10–14-seriata; teniola distincta, flavida, marginata, 4–5-seriata.

Laxly gregarious plants, olivaceous tinged with brown. Stems about 1 cm. high, simple. Leaves curved when dry, spreading when moist, 3–3.5 mm. long and slightly over 0.5 mm. wide at the broadest part of the blade, abruptly oblong-ovate from a short, broad, obcuneate base, broadly acute; margins erect, minutely toothed in the median portion, narrowly winged above and serrate with the teeth in pairs, denticulate and undulate at the leaf shoulders; cells rounded, 8–10 μ, convex on the free surfaces, not incrassate; costa strong, brownish, percurrent, smooth below, papillose above and toothed on the back near the apex. Cancellina forming a short obovate group rounded above and extending scarcely half way up the leaf base, sharply differentiated from the lamina cells; teniola distinct, forming a yellowish border 4 or 5 rows wide at the leaf shoulders and entirely marginal without any shorter cells along the outer edges. Fruit unknown.

Brazil-British Guiana Boundary: Akarai Mountains, height of land between drainage of Rio Mapuera (Trombetas tributary) and Shodikar Creek (Essequibo tributary), dense forest, on tree trunk alt. 600–800 m., *A. C. Smith 2985*, type Jan. 19, 1938.

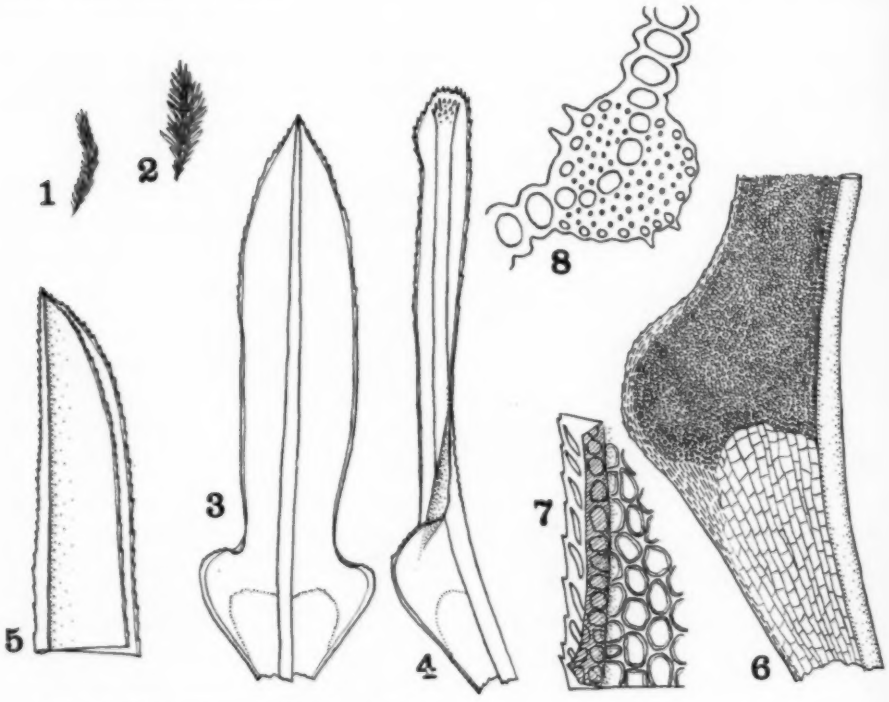

Fig. 1. *Calymperes Smithii* Bartram
1. Dry plant (×1⅓).
2. Moist plant (×1⅓).
3. Leaf (×24).
4. Abnormal leaf (×24).
5. Apex of leaf (×63).
6. One side of leaf base (×63).
7. Leaf cells and margin about one-third down (×330).
8. Cross section of costa, upper half of leaf (×330).

This species differs widely from *C. Sprucei* Besch., as represented by Spruce's Musc. Amaz. et And. 20, in the short, obcuneate leaf base with the cancellina group extending only about half way up to the leaf shoulders, the marginal teniolae and the strongly serrate apical margins of the blade.

Calymperes Donnellii Aust. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on tree trunks, alt. 700 m., *3325a*, *3198*, on rocks.

Distribution: Florida, Antilles, northern South America, Central America, Cocos Island.

Calymperes nicaraguense Ren. & Card. Basin of Essequibo River, lat. about 6°7′N., Head Falls, on humus, edge of forest, *2105*.

Distribution: British Honduras, Nicaragua, Guatemala, Costa Rica.

Calymperes disciforme C. M. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on tree trunks, alt. 650 m., *3676a*, mixed with *Octoblepharum albidum*.

Distribution: Santo Domingo, Panama, Colombia.

Calymperes lonchophyllum Schwaegr. Basin of Essequibo River, near mouth of Onoro Creek, lat. about 1°35′N., dense forest, on tree trunks along river, *2688*. Brazil-British Guiana Boundary: Akarai Mountains, height of land between drainage of Rio Mapuera (Trombetas tributary) and Shodikar Creek (Essequibo tributary), dense forest on tree trunk, alt. 600–800 m., *2994*.

Distribution: Antilles, British Honduras, Guatemala, Costa Rica, Venezuela, Brazil.

POTTIACEAE

Hyophila tortula (Schwaegr.) Hampe. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on exposed rock ledges, alt. 300 m., *3132*.

Distribution: wide in tropical America, eastern and southern United States, central Europe.

Bryum coronatum Schwaegr. Basin of Rupununi River, near mouth of Charwair Creek, lat. about 2°35′N., on fallen tree, forest, *2338*. Basin of Rupununi River, Wichabai, lat. about 2°52′N., on humus, patch of forest in savanna, *2295*.

Distribution: Cosmopolitan in tropical regions extending north to Florida.

Rhodobryum Beyrichianum (Hornsch.) Par. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on decaying log, alt. 600 m., *3282*.

Distribution: tropical and subtropical South America, north to Central America and Mexico.

ORTHOTRICHACEAE

Macromitrium mucronifolium (Hook. & Grev.) Schwaegr. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on tree trunk, alt. 400 m., *3148*. Northwestern slopes of Kanuku Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on tree trunks, alt. 150–400 m., *3481*, *3544a*.

Distribution: Florida, Antilles, Mexico to Ecuador, Galapagos Islands.

Macromitrium stellatum (Hook. & Grev.) Brid. Basin of Rupununi River, near mouth of Charwair Creek, lat. about 2°35′N., on tree trunks, forest, *2339a*, *2382*. Northwestern slopes of Kanuku Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on tree trunk, *3544*.

Distribution: Brazil, Bolivia. If *Macromitrium tumidulum* Mitt. proves to be synonymous with this species, as seems very probable, the range would include Peru, Jamaica and Haiti.

LEUCODONTACEAE

Pseudocryphaea flagellifera (Brid.) E. G. Britt. Northwestern slopes of Kanuku Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on twigs, alt. 150–400 m., *3546*.

Distribution: Florida, Antilles, Brazil, Mexico, Guatemala, Costa Rica.

PTEROBRYACEAE

Orthostichopsis crinita (Sull.) Broth. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on twigs, alt. 700 m., *3604*.

Distribution: Cuba, Venezuela, Peru, Ecuador, Bolivia.

Orthostichopsis tetragona (Sw.) Broth. Northern slope of Akarai Mountains, in drainage of Shodikar Creek (Essequibo tributary), dense forest, on tree trunk, alt. *300–600* m., *2918*.

Distribution: Antilles, northern South America, Mexico, Central America.

Pireella cymbifolia (Sull.) Card. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on tree trunk, alt. 200 m., *3248a*.

Distribution: Florida, Alabama, Louisiana, Antilles, Mexico to Costa Rica. Just a few plants growing with *Neckeropsis undulata*, but enough to establish a new record for South America, as far as I know.

METEORIACEAE

Meteoriopsis patula (Hedw.) Broth. Northwestern slopes of Kanuku Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on twigs, alt. 150–400 m., with *Pseudocryphaea flagellifera*, *3546a*.

Distribution: wide in tropical America, north to Florida.

NECKERACEAE

Neckeropsis undulata (Hedw.) Reichdt. Western extremity of Kanuku

Mountains, in drainage of Takutu River, dense forest, on tree trunk, *3248*.

Distribution: wide in tropical America, north to Florida.

PILOTRICHACEAE

Pilotrichum bipinnatum (Schwaegr.) Brid. Basin of Essequibo River, near mouth of Onoro Creek, lat. about 1°35′N., on twigs, in swamp, *2795*.

Distribution: Antilles, Brazil, Venezuela, Nicaragua to Peru.

HOOKERIACEAE

Callicostella rufescens Mitt. Basin of Shodikar Creek (Essequibo tributary), lat. about 1°18′N., dense forest, on tree trunks, on low land, *2856*.

Distribution: Trinidad, Surinam, Brazil, Ecuador.

Callicostella depressa (Hedw.) Jaeg. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on decayed log, alt. 600 m., *3194*.

Distribution: Antilles.

Hookeropsis Parkeriana (Hook.) Jaeg. Basin of Essequibo River, near mouth of Onoro Creek, lat. about 1°35′N., on twigs, in swamp, *2793*.

Distribution: Barbados to eastern Brazil.

PLAGIOTHECIACEAE

Stereophyllum leucostegium (Brid.) Mitt. Basin of Rupununi River, near mouth of Charwair Creek, lat. about 2°35′N., on rocks, edge of forest, *2369*.

Distribution: wide, Antilles to Brazil, Mexico to northern South America.

Stereophyllum radiculosum (Hook.) Mitt. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on boulders, alt. 700 m., *3326*.

Distribution: Mexico to Peru, Venezuela, Brazil.

Pilosium flaccisetum C.M. Basin of Essequibo River, near Mouth of Onoro Creek, lat. about 1°35′N., on decayed wood in swamp, *2748*.

Distribution: Endemic?

SEMATOPHYLLACEAE

Rhaphidorrhynchium subsimplex (Hedw.) Broth. Basin of Kuyuwini River (Essequibo tributary), about 150 miles from mouth, dense forest, on tree trunks and decaying wood, *2520*, *2525*, *2604*. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, alt. 150–200 m., on tree trunks, *3088*, *3357*. Northwestern slopes of Kanuku

Mountains, in drainage of Moku-moku Creek (Takutu tributary), dense forest, on tree trunks, alt. 150–400 m., *3415*. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on decaying bark, alt. 900 m., *3630*. Brazil-British Guiana Boundary: Akarai Mountains, height of land between drainage of Rio Mapuera (Trombetas tributary) and Shodikar Creek (Essequibo tributary), dense forest, on decaying wood, alt. 600–800 m., *2976*.

Distribution: wide in tropical America.

Sematophyllum loxense (Hook.) Mitt. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on humus, alt. 650 m., *3672a*.

Distribution: wide in tropical America.

Sematophyllum caespitosum (Hedw.) Mitt. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on rocks, alt. 200 m., *3220*.

Distribution: wide in tropical America, north to Florida.

Rhaphidostichum (*Rhaphidostichella*) **guianense** sp. nov. (fig. 2). Autoicum; caespitosum, caespitibus depressis, sat densis, fuscescenti-viridibus, nitidus. Caulis elongatus, inferne denudatus, irregulariter ramosus, ramis vix 1 cm. longis, cuspidatis. Folia patentia, ecostata, oblongo-ovata, 2–2.3 mm. longa et 0.65 mm. lata, sensim in acumen subintegerrimum contracta; marginibus erectis, superne late inflexis, integerrimis vel prope apicem minutissime denticulatis; cellulae lineares, laevissimae, haud incrassatae, alares 3 vel 4, magnae, oblongae, aurantiacae. Perichaetii brachteae erectae, ad 2 mm. longae, internae longe acuminatae, superne denticulatae; seta circa 2 cm. longa, superne humiliter pustulosa; theca horizontalis, minuta, deoperculata 1 mm. longa.

Autoicous; brownish green, glossy plants, paler at the tips, growing in rather dense tufts or mats. Stems elongate, creeping, denuded of leaves below, irregularly branched, the branches scarcely 1 cm. long, densely foliate, cuspidate at the tips, about 3 mm. wide with leaves. Leaves crowded, spreading, ecostate, oblong-ovate, concave, 2–2.3 mm. long and 0.65 mm. wide, gradually contracted to a rather short, nearly entire, sharply pointed acumen; margins erect, often broadly inflexed above, entire or minutely denticulate in the upper third; cells linear, smooth, not incrassate, alar group of 3 or 4 large oblong cells, usually deeply colored. Perichaetium erect, about 2 mm. high, the inner leaves gradually contracted to a long denticulate acumen. Seta about 2 cm. high, very indistinctly pustulose toward the apex; capsule horizontal, ovoid with a short neck, the urn 1 mm. long; peristome teeth with a fine zigzag median line.

Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, alt. 250 m., on rocks, *3119*. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on rocks, alt. 900 m., *3632a*, *3635*, type (Apr. 22, 1938), on decayed wood.

Although evidently allied in leaf structure to *R. Schwaneckianum* C.M. of Cuba and Puerto Rico, this species is quite distinct in the autoicous inflorescence and the shorter, less ligulate and nearly entire leaf acumen.

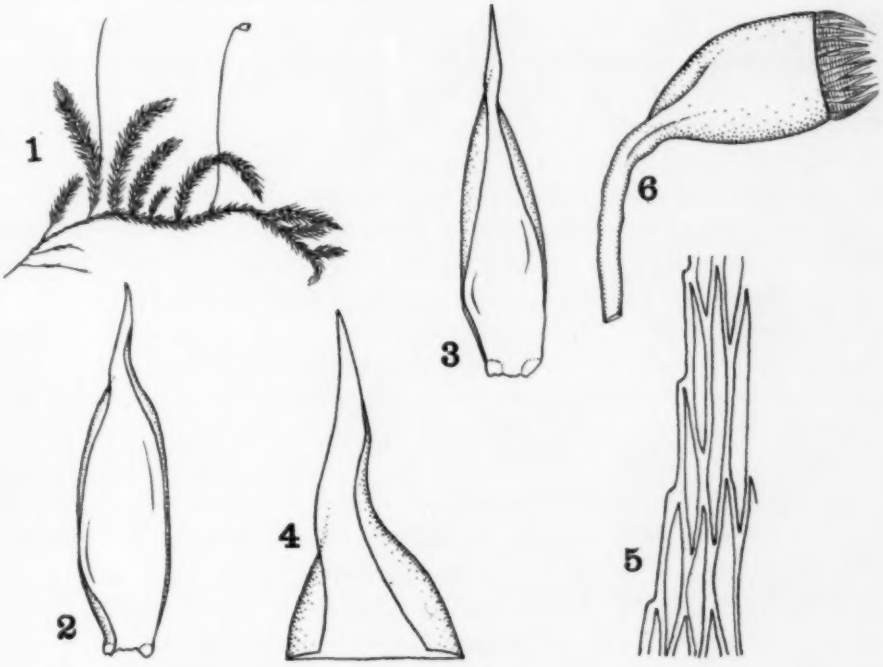

Fig. 2. *Rhaphidostichum guianense* Bartram
1. Plant (×1⅓).
2, *3*. Leaves (×22).
4. Apex of leaf (×63).
5. Upper leaf cells and margin (×330).
6. Moist capsule (×20).

Acroporium guianense (Mitt.) Broth. Brazil: State of Para: southern slope of Akarai Mountains, in drainage of Rio Mapuera (Trombetas tributary), dense forest, on bark of tree, alt. 500–700 m., *2949a*.

Distribution: Guiana, Brazil.

Acroporium pungens (Hedw.) Broth. Basin of Kuyuwini River (Essequibo tributary), about 150 miles from mouth, dense forest, on fallen log, *2636*. Basin of Essequibo River, near mouth of Onoro Creek, lat. about 1°35′N., dense forest, on twigs, on high land, *2760*.

Distribution: wide in Antilles and tropical America.

Potamium vulpinum (Mont.) Mitt. Basin of Kuyuwini River (Essequibo tributary), about 150 miles from mouth, dense forest, on dead branches along river, *2565*.

Distribution: French Guiana, Brazil.

Taxithelium planum (Brid.) Mitt. Basin of Essequibo River, lat. about 6°7′N., Head Falls, on humus, edge of forest, *2107*, a closely pinnate, plumose form. Basin of Rupununi River, near mouth of Charwair Creek, lat. about 2°35′N., on tree trunks, wet forest, *2383*. Basin of Rapununi River, Isherton, lat. about 2°20′N., on decaying wood, dense forest, *2498*. Basin of Kuyuwini River (Essequibo tributary), about 150 miles from mouth, dense forest, on decaying wood, *2546*, *2574*. Basin of Essequibo River, near mouth of Onoro Creek, lat. about 1°35′N., dense forest on tree trunks along river, *2649*, *2655*, on rocks and sand along river, *2644*, on decayed log along river. Basin of Shodikar Creek (Essequibo tributary), lat. about 1°18′N., on decaying log, *2878*. Northern slope of Akarai Mountains, in drainage of Shodikar Creek (Essequibo tributary), dense forest, on tree roots, *2895*.

Distribution: wide in tropical America, north to Florida.

Trichosteleum ambiguum (Schwaegr.) Broth. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on tree trunks, alt. 900 m., *3629*. Brazil-British Guiana Boundary: Akarai Mountains, height of land between Rio Mapuera (Trombetas tributary) and Shodikar Creek (Essequibo tributary), dense forest, on bark of tree, alt. 600–800 m., *2975a*.

Distribution: Brazil, Peru.

HYPNACEAE

Rhacopilopsis trinitensis (C.M.) E. G. Britt. & Dix. Northwestern portion of Kanuku Mountains, Mount Iramaikpang, dense forest, on tree trunk, alt. 850 m., *3618*.

Distribution: Costa Rica, Panama, Trinidad, French Guiana, tropical Africa, Madagascar.

Vesicularia amphibola (Spr.) Broth. Basin of Shodikar Creek (Essequibo tributary), lat. about 1°18′N., dense forest, on sand-covered log, low land, *2854*.

Distribution: Florida, Antilles, Brazil.

Mittenothamnium diminutivum (Hampe) E. G. Britt. Basin of Rupununi River, Isherton, lat. about 2°20′N., on tree trunk, dense forest. *2497*. Western extremity of Kanuku Mountains, in drainage of Takutu River, dense forest, on log and tree trunk, alt. 200–600 m., *3093*, *3197*.

Distribution: wide in tropical America, north to Florida.

BUSHKILL, PA.

Studies of South American Plants—VI. Preliminary notes on Hippocrateaceae

A. C. Smith

The tropical American species of Hippocrateaceae have been much neglected, having been studied in detail only by Miers[1] and Peyritsch,[2] neither of whose works is adequate for a present understanding of the American species. Considerable disagreement as to generic limits is apparent, not only in these two works, but in earlier considerations of the family. The 17 genera recognized by Miers were distributed between *Hippocratea* and *Salacia* by Peyritsch. The present writer is inclined to agree with Peyritsch's treatment, at least for the present, although it must be admitted that many of Mier's genera have clear-cut floral characters which, if magnified many times, might be thought generic by most botanists. This attitude must be modified, however, by the inclusion of several species which appear to break down parts of Miers' classification. The writer plans to undertake monographic work on the family in the near future and will appreciate the long-term loan of American material.

Recent collections in Amazonian Brazil by Mr. B. A. Krukoff have disclosed no fewer than 17 undescribed species of *Salacia*. The fact that these collections have nearly doubled the number of known Amazonian species of the genus will readily be understood by those familiar with tropical collecting. The species of *Salacia* are for the most part high-climbing lianas with very small inconspicuous flowers; such plants are obtainable only by chance unless the collector is making a systematic exploration of high forest trees and lianas, with a large crew at his disposal. During his trip to the Solimoes region in 1936 Mr. Krukoff was paying close attention to the Hippocrateaceae, at the writer's request, and this work was facilitated by his search for species of *Strychnos* and Menispermaceae, plants of similar habit.

The present paper is planned to propose these 17 species, all of which were collected in Brazil; all types are deposited in the herbarium of the New York Botanical Garden, and duplicates are widely distributed. The remaining Amazonian species, including a few from Peru and Venezuela which may be expected in adjacent Brazil, are listed. In the discussions which follow, all mention of Miers and Peyritsch refers to their works above listed. In the key, the generic names in parentheses refer to Miers'

[1] Miers, J. On the Hippocrateaceae of South America. Trans. Linn. Soc. **28:** 319–432. *pl. 16–32.* 1872.

[2] Peyritsch, J. Hippocrateaceae. Mart. Fl. Bras. **11**(1): 125–164. *pl. 42–49.* 1878.

treatment. Mention of fruit characters is omitted from the key, since fruit of only a few species is known.

KEY TO THE AMAZONIAN SPECIES OF SALACIA

Stigmas opposite the stamens.
Disk discontinuous, forming staminiferous pockets.
Stamens, stigmas, and locules 3 (*Kippistia*).
Stigmas narrow, often linear, not lobed.
Inflorescence paniculate, the primary rachis straight and obvious; usually shrubs or small trees.
Young branchlets terete; venation of leaf blades often obscure; petals opaque.... 1. *S. cognata.*
Young branchlets angled; venation of leaf blades conspicuous; petals lineolate.... 2. *S. lineolata.*
Inflorescence dichotomously branching; lianas.
Internodes of inflorescence freely articulate, very short; leaf margins serrate..... 3. *S. articulata.*
Internodes of inflorescence not articulate; leaf margins entire or obsoletely crenate.
Peduncles solitary in leaf axils, several times dichotomously branched.
Leaf blades with obscure veinlets; inflorescence broadly spreading and more or less hemispherical, 9- or 10-times dichotomously branched..... 4. *S. diffusiflora.*
Leaf blades with prominulous veinlets; inflorescence stiff, not conspicuously spreading, 5–7-times dichotomously branched..... 5. *S. minutiflora.*
Peduncles several from base of inflorescence, once or twice dichotomously branched..... 6. *S. pedunculata.*
Stigmas broad, bilobed.
Leaf blades elliptic-oblong; inflorescence 1.5–2.5 cm. long, not conspicuously divaricate; petals glabrous..... 7. *S. Krukovii.*
Leaf blades broadly elliptic; inflorescence 6–8 cm. long, divaricately branched; petals minutely pilose without..... 8. *S. divaricata.*
Stamens, stigmas, and locules 5 (*Cheiloclinium*)..... 9. *S. anomala.*
Disk continuous, short tubular (*Amphizoma*).
Stigmas bilobed.
Petioles 4–8 mm. long; inflorescence slender, lax, the flowers long (6–8 mm.) pedicellate..... 10. *S. laxiflora.*
Petioles 10–15 mm. long; inflorescence stiff, the flowers short (1–3 mm.) pedicellate..... 11. *S. Martiana.*
Stigmas entire..... 12. *S. congestiflora.*
Stigmas alternate with the stamens or obscure.
Disk short tubular, thin carnose or submembranous.
Anther locules contiguous, dehiscing by confluent horizontal clefts, the connective obscure (*Tontelea*).
Stigmas obvious, entire.
Leaf blades ovate- or elliptic-oblong, 8–17 by 2.5–7 cm.; flowers 3–4 mm. in diameter; petals entire or erosulous..... 13. *S. attenuata.*
Leaf blades lanceolate- or elliptic-oblong, 8–9 by 2.5–3.5 cm.; flowers about 3 mm. in diameter..... 14. *S. corymbosa.*
Leaf blades broadly elliptic-oblong, 16–25 by 6–12 cm.; flowers about 2 mm. in diameter; petals erose-fimbriate..... 15. *S. mauritioides.*
Stigmas obscure.
Inflorescence lax, long (to 9 cm.) pedunculate; flowers 6–7 mm. in diameter; leaves chartaceous, conspicuously veined..... 16. *S. cylindrocarpa.*

Inflorescence short (to 2 cm.) pedunculate; flowers not more than 4 mm. in diameter.
Petioles 10–13 mm. long; leaf blades obtuse at base, smooth; sepals pilose within.... 17. *S. nectandrifolia.*
Petioles 13–25 mm. long; leaf blades attenuate or acute at base, rugulose; sepals glabrous.... 18. *S. petiolata.*
Anther locules distinct, dehiscing by longitudinal clefts, exceeded by the connective (*Peritassa*).
Disk single.
Inflorescence branches pubescent.... 19. *S. Colasi.*
Inflorescence branches glabrous.
Leaf blades attenuate at base, crenate-serrate at margin.... 20. *S. dulcis.*
Leaf blades rounded to acute at base, entire to undulate-crenate at margin.... 21. *S. laevigata.*
.... 22. *S. amazonica.*
Disk double, forming two concentric rings.... 23. *S. Ulei.*
Disk pulvinate, carnose; flowers often fasciculate.
Disk highly conical-pulvinate (*Thermophila*).
Inflorescence freely branching; disk free at summit.
Leaves chartaceous, not larger than 17 by 10 cm.; flowers 8–11 mm. in diameter; petals plane; disk truncate at apex.... 24. *S. obovata.*
Leaves thick coriaceous, up to 50 by 20 cm.; flowers less than 3 mm. in diameter; petals distally thickened and tuberculate; disk dentate at apex.... 25. *S. acreana.*
Flowers fasciculate; disk adnate to ovary by interstaminal septae.... 26. *S. caloneura.*
Disk annular-pulvinate, broadly expanded at base (*Raddia*).
Flowers fasciculate.
Flowers 26–30 mm. in diameter at anthesis; leaf blades attenuate at base.... 27. *S. macrantha.*
Flowers less than 21 mm. in diameter at anthesis.
Disk 3–5 mm. in diameter; flowers more than 10 mm. in diameter at anthesis.
Flowers on stem; leaf blades narrowly oblong, 3–4.5 cm. broad, subacute or obtuse at base.... 28. *S. cauliflora.*
Flowers axillary; leaf blades rarely less than 5 cm. broad.
Leaf blades rounded and truncate at base, the secondary nerves essentially plane, not conspicuous.
Petals lineolate; leaf blades more than three times as long as broad.... 29. *S. polyanthomaniaca.*
Petals opaque; leaf blades about twice as long as broad... 30. *S. impressifolia.*
Leaf blades obtuse or somewhat rounded at base, the secondary nerves conspicuous.
Pedicels 12–15 mm. long; flowers about 13 mm. in diameter; style short, attenuate; locules about 6-ovulate.... 31. *S. juruana.*
Pedicels 3–3.5 mm. long; flowers 15–18 mm. in diameter; style none; locules 2-ovulate.... 32. *S. gigantea.*
Disk about 2 mm. in diameter; flowers 5–6 mm. in diameter at anthesis.... 33. *S. solimoesensis.*
Flowers in a freely branching inflorescence.
Disk elevated at inner margin; style subulate; petiole 6–10 mm. long... 34. *S. cuspidata.*
Disk flat; style minute; petiole 3–5 mm. long.... 35. *S. gracilis.*

1. SALACIA COGNATA (Miers) Peyr. in Mart. Fl. Bras. **11** (1): 144. 1878. *Elaeodendron macrophyllum* Rusby, Descr. N. Sp. S. Am. Pl. 24. 1920. *Salacia sphaerocarpa* Rusby, Descr. N. Sp. S. Am. Pl. 52. 1920.

Recent collections extend the range of this species, which both Miers and Peyritsch indicated as limited to southeastern Brazil, to Colombia and Tobago. The specimens cited are remarkably uniform and cannot be distinguished from south Brazilian material. The following specimens, from the northern part of the range of the species, are in the herbarium of the New York Botanical Garden:

TOBAGO: *Broadway 4699; Sandwith 1910.* COLOMBIA: Sur de Santander: Magdalena Valley, *Haught 1385.* VENEZUELA: lower Orinoco, *Rusby & Squires 247, 416* (cotypes of *S. sphaerocarpa*). BRITISH GUIANA: *Smith 2486, 3186, 3603.* BRAZIL: Amazonas: basin of Rio Jurua, *Krukoff 4653, 4843;* basin of Rio Madeira, *Rusby 1248* (type of *Elaeodendron macrophyllum*); *Krukoff 6140, 6188, 6393, 6682.* Maranhão: *Froes 1712.*

2. **Salacia lineolata** sp. nov. Frutex vel arbor gracilis ad 10 m. alta ubique glabra, ramis ut videtur interdum scandentibus; ramulis gracilibus juventute quadrangularibus vel leviter 4-alatis viridibus mox teretibus fuscis lenticellis verruculosis, ad axillas paullo dilatatis; foliis oppositis, petiolis crassis rugosis supra canaliculatis 3–7 mm. longis, laminis chartaceis viridibus (subtus pallidioribus) oblongis vel anguste elliptico-oblongis, 14–23 cm. longis, 4–8 cm. latis, basi obtusis petiolo decurrentibus, apice caudato-acuminatis (acumine 15–25 mm. longo augusto obtuso), margine leviter revolutis integris vel apicem versus obscure crenatis, costa utrinque prominente, nervis lateralibus utroque 8–12 arcuato-adscendentibus prope margines obscure anastomosantibus supra conspicue prominulis subtus prominentibus, venulis manifeste subtile reticulatis utrinque prominulis; paniculis axillaribus 1.5–3 cm. longis pauciramosis, bracteis coriaceis elongato-deltoideis acutis 1.7–2 mm. longis; pedicellis rectis circiter 2 mm. longis, bracteolis 2 deltoideis acutis circiter 1 mm. longis margine erosis; sepalis late deltoideo-ovatis, 0.7–1.5 mm. longis, 1.5–2 mm. latis, interdum minute glanduloso-lineolatis, apice rotundatis, margine minute fimbriatis vel erosis; petalis erectis carnosis obovato- vel spathulato-oblongis, 2.3–2.8 mm. longis, 1.4–2.2 mm. latis, extra irregulariter fusco-lineolatis, intra minute scabridulis, apice rotundatis, margine integris; disco inconspicuo carnoso ad 0.3 mm. alto in labia 3 sacciformia staminigera interruptim laxato; staminibus 3, filamentis ligulatis circiter 0.6 mm. longis, antheris transversaliter ellipsoideis circiter 0.2 mm. longis et 0.3 mm. latis; ovario trigone subgloboso sub anthesi circiter 1.4 mm. diametro; stigmatibus 3 summo ovarii radiatim adnatis, circiter 0.4 mm. longis, apice liberis, staminibus oppositis; drupis oblongo-ellipsoideis ad 33 mm. longis et 19 mm. latis (sed haud dubie maturitate majoribus), saepe leviter falcatis, siccitate glaucis vel fuscis, pericarpio coriaceo 0.6–1 mm. crasso valde ruguloso-punctato, seminibus paucis (circiter 5) superpositis ovatis angulatis, 13–15 mm. longis (maturitate majoribus?), in pulpa nidulantibus.

Type, *Krukoff 8853,* collected in Oct.–Dec., 1936, in basin of Creek Belem, Municipality São Paulo de Olivença, basin of Rio Solimoes,

Amazonas. Other collections are: from the type locality, *Krukoff 9009;* from the same general region, near Palmares, *Krukoff 8318;* Territory Acre: basin of Rio Purus, near mouth of Rio Macauhan (tributary of Rio Yaco), *Krukoff 5732*. Description of the fruit is from the last specimen, collected in September, 1933. All are from high forest on terra firma.

S. lineolata belongs to Section I of Peyritsch (the genus *Kippistia* of Miers), being closely related only to *S. cognata* (Miers) Peyr., from which it is readily distinguished by its angled young branchlets, its more conspicuous leaf venation, and its somewhat larger flowers with the petals and often the sepals conspicuously lineolate rather than smooth and opaque. Probably this species is the same as Peyritsch's variety *egensis* of *S. cognata*, based on *Poeppig 2796*, which I have not seen. Its specific rank seems well merited.

3. **Salacia articulata** sp. nov. Frutex scandens ubique glaber; ramulis oppositis divaricatis juventute purpurascentibus leviter angulatis mox teretibus fuscis; foliis oppositis, petiolis plerumque stramineis rugosis supra profunde canaliculatis 7–10 mm. longis, laminis coriaceis siccitate fusco-viridibus elliptico-oblongis, 8–12 cm. longis, 3–5 cm. latis, basi obtusis vel acutis, apice breviter acuminatis (acumine abrupto 5–10 mm. longo subacuto), margine cartilagineo-incrassatis conspicue serratis (serrationibus 5 vel 6 per centimetrum), supra planis nitidis, subtus parce nigro-punctatis, costa utrinque prominente, nervis lateralibus utroque 8–11 arcuato-adscendentibus supra minute prominulis vel leviter insculptis subtus prominulis, venulis immersis; inflorescentiis axillaribus ad 2 cm. longis breviter (ad 6 mm.) pedunculatis repetitim dichotome multiramosis, ramulis minutissime luteo-punctatis, internodiis articulatis 1–2.2 mm. longis et circiter 1 mm. diametro, bracteis coriaceis late ovatis 0.2–0.4 mm. longis; floribus numerosissimis sessilibus, apicem versus in dichotomiis vel summo pedunculorum ultimorum 2–5 congestis, sub anthesi (petalis erectis vel incurvatis) circiter 1.2 mm. diametro; sepalis late deltoideis, 0.5–0.6 mm. longis, 0.7–0.9 mm. latis, apice acutis, margine erosulis; petalis tenuiter carnosis elliptico-oblongis, 1–1.2 mm. longis, 0.7–0.9 mm. latis, apice obtusis vel rotundatis, margine erosulis, basi ad 0.4 mm. angustatis; disco carnoso in labia 3 sacciformia staminigera 0.15–0.2 mm. alta et circiter 0.3 mm. lata interruptim laxato; staminibus 3, filamentis patulis carnosis ligulatis circiter 0.3 mm. longis, antheris reniformibus circiter 0.12 mm. longis et 0.2 mm. latis, per rimas horizontales terminales dehiscentibus; ovario depresso-subgloboso sub anthesi 0.5–0.6 mm. diametro; loculis 3 ut videtur 4-ovulatis; stigmatibus 3 summo ovarii radiatim adnatis, apice liberis, staminibus oppositis.

Type, *Krukoff 8836*, collected Oct.–Dec., 1936, in high forest on terra firma, basin of Creek Belem, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. It is a species of Peyritsch's Section I (*Kippistia* Miers), characterized by minute flowers, finely serrate leaves, and

short and conspicuously articulate sections of its inflorescence branches. Its closest relative is *S. diffusiflora* (Miers) Peyr., a species with less conspicuously toothed leaf margins and larger inflorescences with more numerous flowers and with longer slenderer internodes which are not conspicuously articulate. The distal sections of the inflorescence of the new species are so freely articulate as to become readily detached; thus the inflorescence of dried specimens disintegrates into small clusters of several internodes each.

4. SALACIA DIFFUSIFLORA (Miers) Peyr. in Mart. Fl. Bras. **11** (1): 143. *pl. 45*. 1878. Rio Cassiquiare region of Venezuela.

5. **Salacia minutiflora** sp. nov. Frutex scandens ubique glaber; ramulis fuscis subteretibus juventute complanatis; foliis oppositis, petiolis gracilibus rugosis supra canaliculatis 11–17 mm. longis, laminis chartaceis vel tenuiter coriaceis siccitate viridibus oblongo-ellipticis, 12–16 cm. longis, 4.5–7.5 cm. latis, basi acutis vel obtusis, apice breviter cuspidatis (acumine lato ad 7 mm. longo obtuso), margine leviter revolutis integris vel obsolete crenatis, costa utrinque prominente, nervis lateralibus utroque 8–12 arcuato-adscendentibus utrinque valde prominulis, venulis juventute manifeste reticulatis utrinque prominulis maturitate supra obscuris; inflorescentiis axillaribus solitariis 2–3.5 cm. longis repetitim dichotomo-ramosis; pedunculis crassis 2–4 mm. longis, ramulis superne incrassatis ad nodos crassis, bracteis et bracteolis late ovatis subacutis 0.4–1 mm. longis; floribus in dichotomiis pedicellatis (pedicellis gracilibus 2.5–3 mm. longis) vel summo pedunculorum ultimorum 2 vel 3 sessilibus aggregatis (versimiliter sub anthesi omnino pedicellatis); sepalis deltoideis, 0.7–1 mm. longis et latis, apice rotundatis, minutissime vel obscure luteo-punctatis vel breviter lineolatis; petalis (immaturis) oblongis, 0.7–0.9 mm. longis, circiter 0.8 mm. latis, apice obtusis; disco inconspicuo in labia 3 sacciformia staminigera circiter 0.1 mm. alta et 0.25 mm. lata interruptim laxato; staminibus 3, filamentis minutis, antheris transversaliter ellipsoideis circiter 0.25 mm. latis, per rimas horizontales subapicales dehiscentibus; ovario breviter cylindrico vel trigono summo complanato; loculis 3 stigmatibus alternatis ut videtur 2-ovulatis; stigmatibus 3 summo ovarii radiatim adnatis staminibus oppositis.

Type, *Krukoff 8217*, collected Sept.–Oct., 1936, on terra firma near Palmares, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. Belonging to Section I of Peyritsch (*Kippistia* Miers), the new species is closely related to *S. podostemma* Sandwith, differing by its more compact inflorescence with stouter branches and a very short common peduncle (2–4 mm. rather than 30–50 mm. long). The petals of the new species (although immature) probably even at anthesis are smaller than those of the Guiana species.

6. **Salacia pedunculata** sp. nov. Frutex (demum scandens?) ubique glaber; ramulis fuscis vel cinereis subteretibus ad axillis paullo dilatatis; foliis oppositis, petiolis nigrescentibus striatis supra canaliculatis 10–20 mm. longis, laminis chartaceis vel tenuiter coriaceis siccitate supra viridibus subtus fuscis elongato-ellipticis, 15–25 cm. longis, 4.3–8 cm. latis, basi attenuatis petiolo decurrentibus, apice acuminatis (acumine 1–2 cm. longo obtuso), margine integris leviter revolutis, costa utrinque prominente, nervis lateralibus utroque 8–10 arcuato-adscendentibus prope margines anastomosantibus utrinque valde prominulis, venulis manifeste reticulatis utrinque prominulis; inflorescentiis axillaribus vel e ramulis infra folia orientibus 2–5 cm. longis; pedunculis gracilibus 4–8 e basi distinctis paucifloris semel vel bis dichotome divisis, ad nodos bibracteolatis, bracteolis coriaceis ovato-deltoideis circiter 1 mm. longis; floribus interdum sessilibus in axillis interdum gracile pedicellatis, basi bibracteolatis, juvenilibus solis visis, sub anthesi ut videtur circiter 5 mm. diametro; sepalis deltoideo-ovatis, 1.1–1.3 mm. longis, 1.5–1.8 mm. latis, apice obtusis, margine minutissime ciliolatis; petalis carnosis concavis suborbicularibus, 2–2.3 mm. longis et latis, apice rotundatis, basi ad 0.8–1 mm. angustatis, extra minutissime puberulis vel glabris; disco inconspicuo carnoso in labia 3 sacciformia staminigera interruptim laxato; staminibus 3, filamentis ligulatis, antheris transversaliter ellipsoideis circiter 0.5 mm. longis et 0.7 mm. latis, per rimas horizontales extrorsas dehiscentibus; ovario carnoso subgloboso sub anthesi ut videtur circiter 2 mm. diametro; loculis 3 stigmatibus alternatis ut videtur 6-ovulatis; stigmatibus 3 summo ovarii radiatim omnino adnatis circiter 0.7 mm. longis staminibus oppositis.

Type, *Krukoff 8760*, collected in Oct.–Dec., 1936, in high forest on terra firma, basin of Creek Belem, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. It is a very distinct species of Section I of Peyritsch (*Kippistia* Miers), characterized by large conspicuously nerved leaves and lax few-flowered corymbose inflorescences. From *S. podostemma* Sandwith and *S. minutiflora* (above described), apparently its closest allies, the new species differs by its proportionately narrower leaves and by the form of its inflorescence, which is several-pedunculate from the base, fewer-flowered, and only once or twice dichotomously branched.

7. **Salacia Krukovii** sp. nov. Frutex scandens ubique glaber; ramulis fuscis subteretibus dense et conspicue lenticellatis; foliis oppositis, petiolis gracilibus supra canaliculatis 7–13 mm. longis, laminis tenuiter coriaceis siccitate fuscis elliptico-oblongis, 10–15 cm. longis, 3–4.5 cm. latis, saepe leviter falcatis, basi acutis vel attenuatis et petiolo decurrentibus, apice acuminatis (acumine angusto 10–15 mm. longo obtuso), margine integris saepe conspicue revolutis, costa utrinque prominente, nervis lateralibus utroque 6–9 arcuato-adscendentibus utrinque prominulis, venulis supra obscuris subtus reticulatis

minute prominulis; inflorescentiis axillaribus rigidis 1.5–2.5 cm. longis, a basi dichotome multidivisis, ramulis crassis ad nodos bibracteolatis, bracteolis coriaceis late ovatis ad 0.4 mm. longis; floribus sessilibus plerumque 2–4 summo pedunculorum ultimorum congestis; sepalis deltoideis, 0.5–0.7 mm. longis, 0.7–1 mm. latis, basi obtusis; petalis tenuiter carnosis obovato-oblongis, 1.4–1.6 mm. longis, 0.8–1 mm. latis, apice rotundatis, basi angustatis, margine integris; disco inconspicuo carnoso in labia 3 sacciformia staminigera circiter 0.2 mm. alta et 0.5 mm. lata interruptim laxato; staminibus 3, filamentis ligulatis brevissimis, antheris transversaliter oblongis circiter 0.25 mm. longis et 0.4 mm. latis, per rimas horizontales extrorsas dehiscentibus; ovario depresso-subgloboso sub anthesi circiter 0.8 mm. diametro; loculis 3 ut videtur 4-ovulatis; stigmatibus 3 sessilibus divaricatis complanatis bilobatis circiter 0.2 mm. longis staminibus oppositis.

Type, *Krukoff 8817*, collected Oct.–Dec., 1936, in high forest on terra firma in basin of Creek Belem, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. *S. Krukovii* falls into Section I or Section II of Peyritsch (*Kippistia* or *Amphizoma* of Miers), having certain characters in common with each. The disk is very similar to that of *Kippistia*, but the stigmas are broad and lobed rather than depressed-linear. *Amphizoma*, with which the new species agrees as to stigmas, has an essentially free and not discontinuous disk and a noticeable style. Thus the new species seems to break down some of the distinctions between the two groups. In foliage *S. Krukovii* resembles *S. congestiflora* (below described), from which it differs by its less conspicuous venation, its simpler, less spreading, and fewer-flowered inflorescence, and by disk and stigma characters.

8. **Salacia divaricata** sp. nov. Frutex scandens ubique praeter petala glaber; ramulis gracilibus juventute fusco-olivaceis complanatis demum fuscis teretibus rugosis; foliis oppositis, petiolis gracilibus rugosis supra canaliculatis 10–15 mm. longis, laminis chartaceis siccitate viridibus late ellipticis, 12–14 cm. longis, 5.5–8.5 cm. latis, basi obtusis et petiolo decurrentibus, apice breviter cuspidatis (acumine lato abrupto 5–8 mm. longo obtuso), margine leviter revolutis et undulato-crenatis (dentibus 1 vel 2 per centimetrum), costa utrinque prominente, nervis lateralibus utroque 8–11 patulis prope margines adscendentibus et anastomosantibus utrinque valde prominulis, venulis reticulatis utrinque plus minusve prominulis; inflorescentiis axillaribus 6–8 cm. longis, breviter (1–2 cm.) pedunculatis, dichotome et divaricatim multidivisis, ramulis rectis ad nodos bibracteolatis, bracteolis deltoideis ad 1 mm. longis; floribus sessilibus vel brevissime pedicellatis; sepalis ovatis, circiter 0.7 mm. longis et 0.9 mm. latis, apice rotundatis, marginem versus membranaceis, margine erosulis vel breviter fimbriatis; petalis submembranaceis obovatis, 1.3–1.5 mm. longis et latis, extra distaliter minute fusco-crispato-pilosis, apice

rotundatis, margine integris; disco inconspicuo carnoso in labia 3 sacciformia staminigera circiter 0.1 mm. alta et 0.5 mm. lata interruptim laxato; staminibus 3 patentibus, filamentis carnosis circiter 0.4 mm. longis apice leviter incrassatis, antheris transversaliter ellipsoideis circiter 0.15 mm. longis et 0.2 mm. latis, per rimas horizontales extrorsas dehiscentibus; ovario breviter trigono-cylindrico carnoso sub anthesi circiter 0.8 mm. diametro, summo complanato; loculis 3 stigmatibus alternatis 2-ovulatis; stigmatibus 3 sessilibus complanatis bilobatis staminibus oppositis.

Type, *Krukoff 6351*, collected Sept. 27, 1934, on low terra firma near Tres Casas, Municipality Humayta, basin of Rio Madeira, Amazonas. Like the preceding (*S. Krukovii*), *S. divaricata* shares certain essential floral characters with both *Kippistia* and *Amphizoma*. The two species are quite similar as regards the essential arrangements of disk, stamen, and stigma characters, but differ notably in leaf proportions, venation, and margins, as well as in shape and size of the inflorescence and the presence of pubescence on the petals of the present species.

9. SALACIA ANOMALA (Miers) Peyr. in Mart. Fl. Bras. **11** (1): 144. 1878. Basins of Rio Negro, Rio Madeira, and Rio Purus.

10. SALACIA LAXIFLORA (Benth.) Peyr. in Mart. Fl. Bras. **11** (1): 145. 1878. Lower Amazon region.

11. SALACIA MARTIANA (Miers) Peyr. in Mart. Fl. Bras. **11** (1): 146. 1878. Amazon and Solimoes regions.

12. **Salacia congestiflora** sp. nov. Frutex scandens ubique glaber; ramulis cinereis obscure dense lenticellatis teretibus juventute plus minusve complanatis; foliis oppositis, petiolis rugosis supra canaliculatis 9–14 mm. longis, laminis chartaceis vel tenuiter coriaceis siccitate fusco-viridibus ellipticis vel elliptico-oblongis, 10–15 cm. longis, 4–6.5 cm. latis, basi obtusis vel acutis vel subattenuatis, apice breviter cuspidatis (acumine obtuso vel saepe apiculato), margine integris et leviter revolutis, costa supra acute elevata subtus prominente, nervis lateralibus utroque 9–13 erecto-patentibus prope margines anastomosantibus utrinque valde prominulis, venulis manifeste reticulatis utrinque prominulis; inflorescentiis axillaribus compactis 1–2.5 cm. longis et latis, fere a basi dichotome multidivisis, ramulis crassis cum bracteis pedicellis calycibusque saepe farinoso-ceriferis; bracteis et bracteolis ovato-deltoideis 0.3–0.5 mm. longis; floribus in ramulis ultimis parvis, sub anthesi expansis 3.2–3.7 mm. diametro, breviter (0.5–1.3 mm.) pedicellatis; sepalis deltoideis, 0.4–0.5 mm. longis, 0.6–0.8 mm. latis, apice obtusis vel subacutis, margine integris vel erosulis; petalis tenuiter carnosis oblongis, 1.4–1.8 mm. longis, 0.8–1.3 mm. latis, apice rotundatis vel obtusis, basi leviter angustatis, margine erosulis, utrinque minutissime intra saepe densissime tuberculatis; disco tenuiter carnoso annulari 0.15–0.3 mm. alto; staminibus 3, filamentis ligulatis

suberectis 0.4–0.8 mm. longis, antheris transversaliter oblongis 0.3–0.5 mm. latis, per rimas horizontales extrorsas dehiscentibus; ovario depresso-subgloboso sub anthesi circiter 0.5 mm. diametro; loculis 3 stigmatibus alternatis 4-ovulatis; stylo carnoso circiter 0.2 mm. longo, stigmatibus 3 carnosis deltoideis patulis integris staminibus oppositis circiter 0.2 mm. longis.

Type, *Krukoff 8297*, collected Sept.–Oct., 1936, on terra firma near Palmares, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. Another collection is: Territory Acre: near mouth of Rio Macauhan (tributary of Rico Yaco), basin of Rio Purus, *Krukoff 5613*. It belongs in Peyritsch's Section II (*Amphizoma* Miers), but disagrees with that concept in the following characters: (1) ovary 3- rather than 6-locular, (2) stigmas entire rather than lobed. *S. congestiflora* is a close relative of *S. Martiana* (Miers) Peyr., from which it differs by the above-mentioned characters and also by its short inconspicuous disk and its more compact inflorescence with shorter pedicels.

13. SALACIA ATTENUATA (Miers) Peyr. in Mart. Fl. Bras. **11** (1): 149. 1878. Basins of Rio Negro, Rio Solimoes, and probably Rio Madeira.

14. SALACIA CORYMBOSA Huber, Bol. Mus. Goeldi **4**: 580. 1906. Basin of Rio Ucayali, Peru.

15. SALACIA MAURITIOIDES A. C. Smith, Bull. Torrey Club **60**: 364. 1933. Northern Matto Grosso, Rio Machado region.

16. **Salacia cylindrocarpa** sp. nov. Frutex scandens ubique glaber; ramulis gracilibus juventute olivaceis complanatis mox siccitate cinereis subteretibus interdum dense lenticellatis; foliis oppositis, petiolis rugosis supra profunde canaliculatis 10–16 mm. longis, laminis chartaceis siccitate fusco-olivaceis anguste oblongo-ellipticis, 15–23 cm. longis, 4–7 cm. latis, basi attenuatis et petiolo decurrentibus, apice acuminatis (acumine 8–13 mm. longo minute apiculato), margine integris et leviter revolutis, costa utrinque prominente, nervis lateralibus utroque 5–7 arcuato-adscendentibus utrinque valde prominulis, venulis copiose et conspicue reticulatis utrinque prominulis; inflorescentiis axillaribus laxis 7–13 cm. longis, pedunculo ramulisque gracilibus; pedunculo ad 9 cm. longo, ramulis secundariis laxe divaricatis paucifloris apicem versus subdichotome paucidivisis; bracteolis submembranaceis oblongo-deltoideis ad 0.7 mm. longis margine erosulis; pedicellis gracilibus sub anthesi 6–10 mm. longis, floribus expansis 6–7 mm. diametro; sepalis ovato-deltoideis vel obovatis, 0.7–1.2 mm. longis, 1.3–1.8 mm. latis, apice rotundatis, marginem versus membranaceis, margine erosulis vel breviter fimbriatis; petalis tenuiter carnosis vel submembranaceis obovatis, 2.8–3.5 mm. longis et latis, obscure nervatis, apice rotundatis, margine integris et leviter revolutis, basi ad 0.8 mm. conspicue angustatis; disco tenuiter carnoso annulari breviter cylindrico, 0.2–0.3 mm. alto, 1.2–1.4 mm. diametro; staminibus 3 erecto-

patentibus, filamentis ligulatis 0.6–0.7 mm. longis, antheris transversaliter ellipsoideis circiter 0.15 mm. longis et 0.3 mm. latis, loculis leviter divergentibus per rimas horizontales apicales dehiscentibus; ovario in disco immerso, loculis 3, 8(vel 6?)-ovulatis; stylo carnoso gracile conico circiter 0.3 mm. longo, stigmatibus obscuris; drupis (in specimine nostro) geminatis ad apicem ramulorum lignosorum, pedicellis crassis cylindricis ad 18 mm. longis et diametro textura fructibus similibus; drupis maximis indehiscentibus elongato-cylindricis leviter trigonis, ad 11 cm. longis et 4.5 cm. diametro, basi rotundatis, apice obtuse breviter cuspidatis, trilocularibus, dissepimentis demum evanidis; pericarpio duro 2.5–3 mm. crasso extra minute rugoso; seminibus congestis circiter 12–20 angulato-ovatis, extra pulpam involutis, ad 25 mm. longis et 18 mm. latis; testa tenuiter coriacea, cotyledonibus 2 ad 17 mm. longis et 10 mm. latis.

Type, *Krukoff 4559*, collected May 22, 1933, on terra firma near Paranagua, Municipality Teffe, basin of Rio Jurua, Amazonas. On the basis of its flower characters, the new species falls into Peyritsch's Section III (*Tontelea* of Miers), in which it is readily distinguished by foliage and inflorescence characters and by its obscure stigmas. In Miers' treatment it would perhaps be better placed in the genus *Clercia*, but Peyritsch has distributed the eight species there discussed in other sections of *Salacia*. The fruit of *S. cylindrocarpa* is quite unique among the species known to me, and if this character proves to be of basic importance the new species may be found to represent a distinct section.

17. **Salacia nectandrifolia** sp. nov. Frutex scandens ubique praeter sepala glaber; ramulis fuscis subteretibus obscure lenticellatis; foliis oppositis, petiolis crassis rugosis supra canaliculatis 10–13 mm. longis, laminis coriaceis siccitate olivaceis utrinque planis ellipticis vel elliptico-oblongis, 12–18 cm. longis, 5.5–8 cm. latis, basi obtusis et petiolo decurrentibus, apice ut videtur obtuse breviter cuspidatis, margine integris et leviter revolutis, costa utrinque prominente, nervis lateralibus utroque 6–8 adscendentibus utrinque valde prominulis, venulis obscuris vel supra interdum prominulis; inflorescentiis axillaribus 4–6 cm. longis multifloris fere ad basin dichotome multidivisis vel breviter (ad 2 cm.) pedunculatis; bracteis et bracteolis deltoideis 0.4–1.2 mm. longis; floribus sub anthesi expansis 2.2–2.5 mm. diametro, breviter (0.4–0.9 mm.) pedicellatis; sepalis oblongis subacutis, 1–1.2 mm. longis, 0.5–0.7 mm. latis, extra glabris, intra distaliter et margine conspicue pilosis; petalis tenuiter carnosis oblongis magnitudine sepalis aequalibus, apice obtusis, margine minute fimbriatis; disco tenuiter carnoso erecto annulari breviter tubuloso, 0.2–0.3 mm. alto, 0.7–0.8 mm. diametro; staminibus 3 erectis, filamentis ligulatis 0.5–0.6 mm. longis; antheris transversaliter oblongis circiter 0.15 mm. longis et 0.2 mm. latis, per rimas horizontales terminales dehiscentibus; ovario breviter conico basi ad discum adnato; loculis 3, ovulis 2 collateralibus; stylo gracile conico circiter 0.3 mm. longo, stigmatibus obscuris.

Type, *Krukoff 8788*, collected Oct.–Dec., 1936, in high forest on terra firma in basin of creek Belem, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. Due to the fact that more or less parallel series of floral variations exist both in *Salacia* and *Hippocratea*, the exact position of the present species is uncertain, although the fact that the ovary is strictly round rather than trigonous in cross-section indicates that the fruit will not develop as in *Hippocratea*. In *Salacia*, the new species falls into Peyritsch's Section III (*Tontelea* of Miers), in which it is readily distinguished by its leaf texture, its obscure stigmas, and the ciliate or pilose character of its small petals and sepals. If sought in *Hippocratea*, the new species would fall into Section IV of Peyritsch (*Cuervea* Miers), but here it is almost certainly out of place.

18. **Salacia petiolata** sp. nov. Frutex demum scandens ubique glaber; ramulis fusco-cinereis subteretibus ad nodos incrassatis parce lenticellatis; foliis oppositis vel suboppositis, petiolis gracilibus rugosis supra canaliculatis 13–25 mm. longis, laminis chartaceis utrinque minute rugulosis siccitate fuscis vel fusco-olivaceis elliptico-oblongis, 13–21 cm. longis, 5–10 cm. latis, basi attenuatis vel interdum acutis et petiolo decurrentibus apice breviter acuminatis (acumine 5–10 mm. longo obtuso), margine integris et leviter revolutis, costa utrinque prominente, nervis lateralibus utroque 7–9 arcuato-adscendentibus supra prominulis vel leviter impressis subtus elevatis, venulis supra immersis vel subobscuris subtus leviter prominulis vel interdum obsoletis; inflorescentiis axillaribus vel e ramulis infra folia orientibus quam petiolis plerumque brevioribus, breviter (ad 2 mm.) pedunculatis, dichotome multidivisis; bracteis et bracteolis deltoideis 0.4–0.7 mm. longis margine erosis; pedicellis ad 0.5 mm. longis; floribus sub anthesi expansis circiter 4 mm. diametro; sepalis ovato-oblongis circiter 0.7 mm. longis et 0.9 mm. latis, apice rotundatis, margine erosulis; petalis submembranaceis oblongis, 1.5–1.8 mm. longis, circiter 1.1 mm. latis, apice rotundatis, margine integris; disco tenuiter carnoso erecto annulari breviter tubuloso, circiter 0.3 mm. alto et 1.1 mm. diametro; staminibus 3 reflexis, filamentis carnosis ligulatis 0.9–1.1 mm. longis, antheris transversaliter oblongis circiter 0.2 mm. longis et 0.5 mm. latis, per rimas horizontales extrorsas dehiscentibus; ovario trigono-subgloboso sub anthesi circiter 0.6 mm. diametro; stylo carnoso circiter 0.3 mm. longo truncato vel apice obscure trigono; fructibus immaturis subglobosis ad 2 cm. diametro, pedicellis crassis (ad 7 mm. diametro), pericarpio coriaceo extra densissime cinereo-lenticellato.

Type, *Krukoff 5141*, collected June 30, 1933, on terra firma near mouth of Rio Embira (tributary of Rio Tarauaca), basin of Rio Jurua, Amazonas. The fruit described above is from *Krukoff 4755*, from the type locality, which probably belongs here but which differs from the type by its somewhat broader and less conspicuously attenuate-based leaves.

Another specimen which may belong here is *Cardenas 1763*, from Rurrenabaque, basin of Rio Beni, Bolivia; this has an obovoid fruit 4 cm. long with a rugulose elenticellate pericarp, and has smooth rather than rugulose leaves.

Like the preceding (*S. nectandrifolia*), the new species probably belongs in Peyritsch's Section III (*Tontelea* of Miers), but has obscure stigmas, an unusual feature in this section as previously constituted. *S. petiolata* is separable from *S. nectandrifolia* by its long petioles, attenuate leaf bases, rugulose leaf surfaces, and glabrous sepals.

19. SALACIA COLASI R. Ben. Bull. Soc. Bot. France **80**: 335. 1933. Vicinity of Iquitos, Peru.

20. SALACIA DULCIS Benth. in Hook. Kew Journ. **4**: 9. 1852. Basins of Rio Negro, Rio Solimoes, and Rio Madeira.

21. SALACIA LAEVIGATA DC. Prodr. **1**: 570. 1824. Peyritsch has reduced several of Miers' species to this, and a critical evaluation of the complex must await further study. In the broad sense, the species occurs in the lower Amazon, Negro, and Madeira regions.

22. SALACIA AMAZONICA Loes. Verh. Bot. Ver. Brand. **48**: 179. 1907. Basin of Rio Madeira. From the description this is hardly separable from the preceding.

23. SALACIA ULEI Loes. Verh. Bot. Ver. Brand. **48**: 178. 1907. Basin of Rio Jurua.

24. SALACIA OBOVATA (Rich.) Peyr. in Mart. Fl. Bras. **11** (1): 154. 1878. Basins of Rio Solimoes and Rio Madeira. It remains to be seen whether or not Peyritsch's variety *amazonica* is conspecific with typical Guiana material.

25. **Salacia acreana** sp. nov. Frutex scandens ubique glaber; ramulis crassissimis 8–13 mm. diametro juventute olivaceis complanatis mox cinereis subteretibus parce lenticellatis; foliis oppositis, petiolis crassis (5 mm. diametro) rugosissimis supra canaliculatis 3–3.5 cm. longis, laminis crassissime coriaceis siccitate fusco-viridibus utrinque rugosis oblongis vel ovato-oblongis, 40–50 cm. longis, 17–20 cm. latis, basi obtusis vel subtruncatis, margine anguste revolutis integris vel leviter undulatis, costa supra acute prominente subtus crassa prominentissima, nervis lateralibus utroque 14–16 validis rectis erecto-patentibus supra subplanis vel leviter insculptis subtus prominentibus, venulis immersis vel inconspicue reticulatis et leviter depressis; paniculis axillaribus vel e ramulis defoliatis orientibus multifloris, 7–9 cm. longis, 5–7 cm. latis, pedunculo brevi, rhachide tereti crassa ad 6 mm. diametro, ramulis primariis 7–12 alternatis dichotome vel saepe alternatim multiramosis; bracteis et bracteolis coriaceis ovato-deltoideis minutis; pedicellis 1.3–1.5

mm. longis; floribus sub anthesi (petalis erecto-patentibus) 2.2–2.7 mm. diametro; sepalis deltoideis circiter 0.9 mm. longis et 1.4 mm. latis, apice acutis, margine erosulis; petalis tenuiter carnosis oblongis vel obovato-oblongis, 1.5–1.8 mm. longis, 0.9–1.3 mm. latis, intra apicem versus incrassatis et irregulariter transverse valde tuberculatis, apice rotundatis plus minusve patento-reflexis, margine membranaceis et integris; disco carnoso conico-pulvinato 0.4 mm. alto, basi 0.5–0.6 mm. diametro superne angustato, apice lobis 3 deltoideis obtusis circiter 0.1 mm. longis dentato; staminibus 3 intra discum insertis erectis, filamentis carnosis gracilibus circiter 0.7 mm. longis, antheris oblongis circiter 0.15 mm. longis et latis per rimas terminales horizontales dehiscentibus; ovario immerso, cavitate disci occluso, loculis 3, 2-ovulatis; stylo subulato circiter 1mm. longo apice truncato; pedicellis fructiferis crassis 9–12 mm. diametro; drupis maximis indehiscentibus subglobosis maturitate 6–8 cm. diametro siccitate fuscis, pericarpio crasse coriaceo 3–6 mm. crasso minute sed aequabiliter ruguloso; seminibus ut videtur plerumque 3 vel 4 oblongis, siccitate ad 40 mm. longis et 25 mm. latis, in pulpa nidulantibus.

Type, *Krukoff 5423*, collected Aug. 11, 1933, on terra firma near mouth of Rio Macauhan (tributary of Rio Yaco), basin of Rio Purus, Territory Acre. A local name is "Gogo," but probably this applies as well to other species of the genus with large fruits. *S. acreana* is such a remarkably distinct plant as to make comparison with any other described species superfluous. In the shape and texture of the disk, the long filaments, and the tapering style with obsolete stigmas it resembles Peyritsch's Section V (*Thermophila* Miers). It differs from the species of that section by having the inflorescence with a stout rachis and many lateral branches, the flowers comparatively minute, the petals thickened and tuberculate within distally, the disk not expanded at base and dentate at apex, the anther locules connate with apical clefts, and the fruit comparatively very large. In view of these numerous and important differences, as well as others in leaf size and texture, it seems that a new section will be required for this species when the genus has been properly revised.

26. **Salacia caloneura** sp. nov. Frutex scandens ubique glaber; ramulis fuscis striatis subteretibus, ad nodos incrassatis et complanatis, lenticellis parvis dense obtectis; foliis oppositis, petiolis rugosis gracilibus supra profunde canaliculatis 13–17 mm. longis, laminis tenuiter coriaceis siccitate supra viridibus subtus fuscis elliptico-oblongis saepe basin versus complicatis, 8–12 cm. longis, 4–5.5 cm. latis, basi rotundatis vel obtusis, apice breviter acuminatis (acumine ad 5 mm. longo obtuso), margine leviter undulatis vel obscure crenatis, costa utrinque prominente, nervis lateralibus utroque 10–13 prope margines adscendentibus et anastomosantibus utrinque valde prominulis, venulis conspicue reticulatis utrinque prominulis; pedunculo axillari gemmi-

formi, bracteis numerosis coriaceis minutis deltoideis; floribus 3–8 per fasciculum, pedicellis et calycibus dense farinoso-ceriferis; pedicellis gracilibus 4–7 mm. longis; sepalis papyraceis vel siccitate tenuiter coriaceis late reniformi-ovatis, 1.3–1.5 mm. longis, 3–3.5 mm. latis, debile nervatis, apice rotundatis, margine integris; petalis sub anthesi rotatis tenuiter carnosis obovato- vel oblongo-spathulatis, 3–3.5 mm. longis et latis, basi ad 1 mm. angustatis, apice rotundatis, margine integris et scariosis; disco carnoso conico-annulari-pulvinato circiter 1 mm. alto, basi 2.5–3 mm. apice circiter 1.3 mm. diametro, per septa inter stamina ad ovarium adnato; staminibus 3 intra discum insertis, filamentis ligulatis 0.8–1 mm. longis et 0.4 mm. latis, antheris transversaliter oblongis circiter 0.2 mm. longis et 0.5 mm. latis, per rimas horizontales subterminales dehiscentibus; ovario in disco immerso subgloboso, loculis 3 circiter 8-ovulatis, ovulis 2-serialibus; stylo carnoso tenuiter conico 0.4–0.5 mm. longo, stigmatibus obscuris.

Type, *Krukoff 8696*, collected Oct.–Dec., 1936, in high forest on terra firma in basin of Creek Belem, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. It is a species without close allies, by its fasciculate flowers suggesting *Raddia*, but clearly separable from the species of that section by the shape of its disk, as well as by its leaf shape and texture, its conspicuous secondary nerves, and its broad sepals. Probably it is better placed in Peyritsch's Section V (*Thermophila* Miers), from the species of which it is distinguished by its fasciculate flowers and by the disk being adnate to the ovary by septae, thus forming pockets for the stamens. This form of disk is not otherwise found among the Amazonian species.

27. **Salacia macrantha** sp. nov. Frutex (demum scandens?) ubique glaber ad 6 m. altus; ramulis fuscis rugosis striatis subteretibus parce lenticellatis; foliis oppositis, petiolis crassis (ad 4 mm. diametro) rugosis supra canaliculatis 7–20 mm. longis, laminis coriaceis siccitate supra glaucis subtus fusco-glaucis anguste oblongis vel obovato-oblongis, 15–25 cm. longis, 4.5–8 cm. latis, basi attenuatis petiolo decurrentibus, apice ut videtur breviter et obtuse acuminatis, margine integris et leviter revolutis, costa utrinque acute prominente, nervis lateralibus utroque 7–10 adscendentibus prope margines obscure anastomosantibus supra prominulis vel leviter depressis subtus conspicue elevatis, venulis reticulatis utrinque obscuris vel leviter insculptis; inflorescentiis completis non visis, floribus expansis 26–30 mm. diametro; sepalis tenuiter coriaceis late ovatis, 3–3.5 mm. longis, 3.5–4 mm. latis, apice rotundatis, margine integris et saepe scariosis; petalis papyraceis vel submembranaceis luteis sub anthesi rotatis obovato-oblongis, 12–13 mm. longis, 9–10 mm. latis, debile nervatis, apice rotundatis, margine integris, basi 1–2 mm. disci margine obtectis; disco annulari-pulvinato complanato 6–8 mm. diametro, centrum versus carnoso, margine conspicue complanato et mem-

branaceo; staminibus 3 patulis, filamentis ligulatis 2.4–2.7 mm. longis, basi circiter 1 mm. distaliter 0.5 mm. latis, antheris transversaliter ellipsoideis circiter 0.6 mm. longis et 0.9 mm. latis, per rimas extrosas latas dehiscentibus; ovario carnoso trigono sub anthesi circiter 2 mm. diametro, basi in disco immerso, loculis 3 ut videtur 6-ovulatis; stylo carnoso circiter 0.4 mm. longo apice obscure trigono.

Type, *Krukoff 4547*, collected May 22, 1933, on terra firma near Paranagua, basin of Rio Jurua, Municipality Teffe, Amazonas. Although the present material is incomplete (of the inflorescence only a few detached flowers being available), it is sufficient to indicate that an undescribed species of Peyritsch's Section VI (*Raddia* Miers) is represented. *S. macrantha* is characterized by its remarkably large flowers, which considerably exceed in dimensions those of the related Amazonian species. From these the new species also differs by its leaf texture, color, venation, shape, and attenuate rather than rounded base.

28. **Salacia cauliflora** sp. nov. Frutex scandens ubique glaber; ramulis elongatis gracilibus striatis subteretibus, ad nodos incrassatis, lenticellis parvis hinc inde obtectis; foliis oppositis, petiolis rugosis nigrescentibus supra canaliculatis 5–10 mm. longis, laminis tenuiter coriaceis siccitate fuscis oblongis vel lanceolato-oblongis, 10–15 cm. longis, 3–4.5 cm. latis, basi obtusis vel subacutis, apice cuspidatis vel breviter acuminatis (acumine ad 12 mm. longo saepe calloso-apiculato), margine integris leviter undulatis, costa utrinque prominente, nervis lateralibus utroque 10–12 patulis supra minute impressis subtus inconspicue elevatis vel utrinque obscuris, venulis immersis vel supra leviter impresso-reticulatis; inflorescentiis multifloris glomerulatis e ramis vetustis orientibus, pedunculis congestis, bracteis numerosis coriaceis minutis deltoideis; pedicellis et calycibus parce et decidue farinoso-ceriferis; pedicellis gracilibus sub anthesi 15–20 mm. longis; sepalis tenuiter coriaceis late semiorbiculari-ovatis, apice rotundatis, margine integris scariosis, 2 vel 3 exterioribus 1.4–2 mm. longis et 1.8–2.2 mm. latis, interioribus 2.6–2.7 mm. longis, 3.5–4 mm. latis; petalis sub anthesi rotatis carnosis orbiculari-ovatis, 5–5.5 mm. longis et latis, apice rotundatis, basi ad 1.5 mm. angustatis, margine integris; disco carnoso annulari-pulvinato, basi 3–4 mm. apice 1.5–2 mm. diametro; staminibus 3 reflexis, filamentis ligulatis 1.7–1.9 mm. longis, antheris transversaliter ellipsoideis circiter 0.2 mm. longis et 0.5 mm. latis, per rimas horizontales terminales dehiscentibus; ovario in disco immerso, loculis 3 circiter 8-ovulatis, ovulis 2-serialibus; stylo carnoso brevi conico, stigmatibus obscuris.

Type, *Krukoff 8202*, collected Sept.–Oct., 1936, on terra firma near Palmares, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. Belonging to Peyritsch's Section VI (*Raddia* Miers), the new species is characterized by its scandent cauliflorous habit and its narrow

and obscurely nerved leaves. These points distinguish it from the allied *S. juruana* Loes. and *S. polyanthomaniaca* Barb. Rodr., both of which also have larger flowers and longer petioles than *S. cauliflora*.

29. SALACIA POLYANTHOMANIACA Barb. Rodr. Vellosia **1**: 15. *pl. 8.* 1888. *Anthodon grandiflorus* Benth. in Hook. Kew Journ. **4**: 10. 1852. *Salacia grandiflora* Peyr. in Mart. Fl. Bras. **11** (1): 157. 1878. Not *S. grandiflora* Kurz (1872).

Although the type of Barbosa Rodrigues' species is not available, there seems little doubt from his description and plate that it is the same as *S. grandiflora* (Benth.) Peyr. Both types are from the vicinity of Manaos; that of Barbosa Rodrigues' is said to be from a liana, that of Bentham's from a tree. The shrubs and slender trees of *Salacia* often become highly scandent, so this character is not to be trusted.

30. **Salacia impressifolia** (Miers) comb. nov. *Raddia impressifolia* Miers, Trans. Linn. Soc. **28**: 392. 1872.

Basin of upper Rio Negro. Peyritsch's reduction of this to the preceding seems unwarranted. However, if the two species should be combined, the present name rather than *S. grandiflora* (Benth.) Peyr. or *S. polyanthomaniaca* Barb. Rodr. must be used.

31. SALACIA JURUANA Loes. Verh. Bot. Ver. Brand. **48**: 181. 1907. Basins of Rio Madeira, Rio Purus, Rio Jurua, and probably Rio Solimoes.

32. SALACIA GIGANTEA Loes. Verh. Bot. Ver. Brand. **48**: 182. 1907. Basin of Rio Jurua.

33. **Salacia solimoesensis** sp. nov. Frutex vel arbor gracilis ad 7 m. alta ubique glabra; ramulis teretibus ad nodos incrassatis, lenticellis parvis parce obtectis; foliis oppositis, petiolis crassis rugosis supra canaliculatis 13–18 mm. longis, laminis coriaceis laevigatis siccitate olivaceis anguste oblongis, 20–27 cm. longis, 5–7 cm. latis, basi rotundatis vel obtusis et petiolo leviter decurrentibus, apice ut videtur breviter obtuse acuminatis, margine integris leviter revolutis, costa utrinque prominente, nervis lateralibus utroque 8–10 arcuato-adscendentibus prope margines obscure anastomosantibus supra paullo elevatis subtus prominulis vel leviter insculptis, venulis immersis vel subtus leviter insculptis; inflorescentiis completis non visis; pedicellis gracilibus sub anthesi 5–7 mm. longis; sepalis oblongis vel deltoideo-ovatis, 1–1.3 mm. longis, circiter 1 mm. latis, apice rotundatis, margine integris; petalis tenuiter carnosis sub anthesi rotatis vel reflexis ovato-oblongis, 2.2–2.6 mm. longis, 2–2.3 mm. latis, apice rotundatis, margine integris, basi ad 0.7–1 mm. angustatis; disco carnoso annulari-pulvinato, circiter 0.5 mm. alto et basi 2 mm. diametro; staminibus 3 suberectis, filamentis ligulatis 0.8–1 mm. longis, antheris transversaliter ellipsoideis circiter 0.15 mm. longis et 0.25 mm. latis, per rimas horizontales terminales dehiscentibus; ovario basi in disco immerso, loculis 3 ut

videtur circiter 4-ovulatis; stylo gracile conico circiter 0.4 mm. longo, stigmatibus obscuris.

Type, *Krukoff 8175*, collected Sept.–Oct., 1936, in high forest on terra firma near Palmares, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. The specimen at hand is very incomplete and only two flowers are available, but from these and the foliage it is obvious that the species belongs in Peyritsch's Section VI (*Raddia* Miers). It is characterized by its long narrow leaves, which most closely resemble in texture and venation those of *S. juruana* Loes. From this, as well as from *S. polyanthomaniaca* Barb. Rodr. and its allies, the new species is distinguished by its small flowers as well as by leaf proportions.

34. **Salacia cuspidata** sp. nov. Frutex scandens ubique glaber; ramulis teretibus fuscis vel cinereis saepe densissime lenticellatis; foliis oppositis, petiolis crassis rugosis leviter canaliculatis 6–10 mm. longis, laminis tenuiter coriaceis siccitate fusco-viridibus oblongo- vel obovato-ellipticis, 11–18 cm. longis, 4.5–8 cm. latis, basi obtusis vel acutis, apice breviter cuspidatis (acumine abrupto 4–10 mm. longo obtuso), margine integris et leviter revolutis, subtus conspicue nigro-punctatis, costa supra paullo subtus valde prominente, nervis lateralibus utroque 8–11 erecto-patentibus prope margines anastomosantibus supra prominulis subtus valde elevatis, venulis reticulatis utrinque prominulis vel supra plerumque immersis; inflorescentiis axillaribus paniculatis 3–4 cm. longis breviter pedunculatis pauciramosis, ramulis rectis gracilibus alternatim vel apicem versus subdichotome divisis, bracteolis tenuiter coriaceis deltoideis 0.4–1 mm. longis; pedicellis gracilibus rectis sub anthesi ad 5 mm. longis; sepalis tenuiter coriaceis deltoideo-ovatis, 0.9–1.1 mm. longis, circiter 1.3 mm. latis, apice subacutis vel obtusis, marginem versus scariosis, margine subreflexis et integris vel erosulis et saepe brevissime fimbriatis; petalis tenuiter carnosis oblongis, 1.8–2 mm. longis, 1.3–1.5 mm. latis, apice rotundatis, margine erosulis vel minute fimbriatis; disco carnoso annulari-pulvinato, circiter 0.4 mm. alto et 1.8 mm. diametro, margine interiore elevato exteriore complanato; staminibus 3, filamentis ligulatis 0.7–0.9 mm. longis, antheris transversaliter ellipsoideis, circiter 0.2 mm. longis et 0.3 mm. latis, loculis plus minusve divergentibus, per rimas transversales apicales dehiscentibus; ovario subgloboso-trigono sub anthesi circiter 0.8 mm. diametro; loculis 3, 2 (vel 1)-ovulatis; stylo subulato carnoso circiter 0.6 mm. longo, stigmatibus obscuris.

Type, *Krukoff 8415*, collected Sept.–Oct., 1936, on varzea land near Palmares, Municipality São Paulo de Olivença, basin of Rio Solimoes, Amazonas. Another collection from the same locality but growing on terra firma is *Krukoff 8255*. It is a species of Peyritsch's Section VI (*Raddia* Miers), in which its freely branching inflorescence separates it from all described species except *S. paniculata* (Mart.) Peyr. From this

S. cuspidata differs by many minor characters, such as its leaf apex, its smaller and differently shaped petals, its less highly elevated disk, and its fewer ovules.

35. **Salacia gracilis** sp. nov. Frutex (demum scandens?) ubique glaber ad 6 m. altus; ramulis gracilibus juventute purpurascentibus ad nodos complanatis mox stramineis teretibus copiose lenticellatis; foliis oppositis, petiolis anguste alatis vel leviter canaliculatis 3–5 mm. longis, laminis chartaceis vel tenuiter coriaceis siccitate supra fusco-viridibus subtus fuscis, obovato-ellipticis, 10–15 cm. longis 3.5–6 cm. latis, basi attenuatis petiolo decurrentibus, apice breviter acuminatis (acumine 6–10 mm. longo apiculato), margine integris et leviter undulatis, costa utrinque prominente, nervis lateralibus utroque 7–9 prope margine conspicue anastomosantibus utrinque valde prominulis, venulis reticulatis utrinque prominulis; inflorescentiis axillaribus 3–5 cm. longis a basi paucidivisis, ramulis gracilibus, internodiis inferioribus ad 14 mm. longis, bracteolis tenuiter coriaceis oblongo-deltoideis 0.7–1.3 mm. longis; pedicellis gracilibus sub anthesi 8–12 mm. longis; sepalis anguste imbricatis ovato-deltoideis, 1.1–1.3 mm. longis, 1.3–1.7 mm. latis, submembranaceis, obscure nervatis, apice rotundatis, margine anguste recurvatis et minute fimbriatis; petalis sub anthesi rotatis tenuiter carnosis vel submembranaceis spathulato-obovatis, 1.9–2.2 mm. longis et latis, apice rotundatis, margine membranaceis et erosis, basi ad 0.8 mm. angustatis; disco carnoso annulari-pulvinato, circiter 0.2 mm. crasso, 2–2.2 mm. diametro; staminibus 3 (raro 4) patulis, filamentis ligulatis 0.4–0.5 mm. longis, antheris rhomboideis, circiter 0.2 mm. longis et 0.5 mm. latis, per rimas horizontales terminales dehiscentibus; ovario depresso-trigono-subgloboso umbonato, sub anthesi circiter 1 mm. diametro; loculis 3, 2-ovulatis; stylo circiter 0.1 mm. longo apice obscure trigono.

Type, *Krukoff 4762*, collected June 12, 1933, on varzea land near mouth of Rio Embira (tributary of Rio Tarauaca), basin of Rio Jurua, Amazonas. It does not readily fall into any of the recognized groups of *Salacia*, being distinct in the form of its annular-pulvinate disk, which is not at all elevated at the inner margin as in Peyritsch's Section VI (*Raddia* Miers). Nevertheless this section appears to be the best place for the new species; a complete revision of the group may indicate the necessity of additional sections. Like *S. paniculata* (Mart.) Peyr. and *S. cuspidata* (above described), but unlike other species of *Raddia*, *S. gracilis* has a freely branching inflorescence. It is at once distinguished by its disk, short style, few ovules, short petioles, and numerous other features.

New York Botanical Garden

INDEX TO AMERICAN BOTANICAL LITERATURE

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

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